PB-240 046

RADIOLOGICAL HEALTH DATA. VOLUME 5, NUMBERS 1-3, JANUARY-MARCH 1964

Public Health Service
Washington, D. C.

March 1964

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET

1. Report No.
RHD 5 (1-3)

2.

PB 240 046

4. Title and Subtitle
Radiological Health Data
Volume 5, Nos 1-3

5. Report Date
Jan-Mar 1964

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Jan-Mar 1964

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented.

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

17c. COSATI Field/Group

PRICES SUBJECT TO CHANGE

18. Availability Statement
Release unlimited

19. Security Class (This Report)
UNCLASSIFIED

20. Security Class (This Page)
UNCLASSIFIED

21. No. of Pages
152

22. Price PC/ MF
6.25 / 2.25

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 1
JANUARY 1964

TABLE OF CONTENTS

Page

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation ---- 1
  1. Radiation Surveillance Network (September 1963), PHS ---- 1
  2. National Air Sampling Network (Third quarter 1963), PHS ---- 5
  3. Canadian Air Monitoring Program (September 1963) ---- 7
  4. Mexican Air Monitoring Program (September 1963) ---- 9
  5. Pan American Air Sampling Program (September 1963), PAHO and PHS ---- 10
  6. Gross Beta Activity in Air, North America (September 1963) ---- 10

Intercalibration of the Major North American Air Monitoring Systems, L. B. Lockhart, Jr. and R. L. Patterson, Jr. ---- 12

Fission Product Gamma Activity in Airborne Particulates—80th Meridian, August 1963, AEC 16

Monthly Deposition of Various Radionuclides ---- 18
  Fallout Measurements in Canada (July–September, 1963) ---- 18

Page

SECTION II.—MILK AND FOOD

Milk Surveillance ---- 19
  1. Pasteurized Milk Network (September 1963), PHS ---- 19
  2. Indiana Milk Network (September 1963) ---- 24
  3. New York Milk Network (August 1963) ---- 24
  4. Radiostrontium in Milk (April-June 1963), AEC ---- 25
  5. Canadian Milk Network (September 1963) ---- 26

Moving Annual Average Radionuclide Concentrations in Pasteurized Milk (October 1962–September 1963) ---- 29

SECTION III.—WATER

Radioactivity in Raw Surface Waters, National Water Quality Network (July 1963), PHS ---- 31

Radiostrontium in Tap Water (January–April 1963), AEC ---- 35

SECTION IV.—OTHER DATA

Preliminary Survey of Dairy Cattle Feeding Practices, C. D. Olsen ---- 37

Environmental Levels of Radioactivity at Atomic Energy Commission Installations ---- 40
  Hanford Atomic Products Operation (Calendar year 1962) ---- 40
  Reported Nuclear Detonations (December 1963) 43

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more intensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. September 1963 data from three networks were combined and are presented graphically by means of isogram lines on a map of North America.

1. RADIATION SURVEILLANCE NETWORK, SEPTEMBER 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) is made up of 73 sampling stations distributed throughout the United States as indicated in figure 1. Most of these stations are operated by State Health Department personnel.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 38,300 pc Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is recounted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = C$ (*1*).[1] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The September 1963 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN

---

[1] In this expression, A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T = 1.

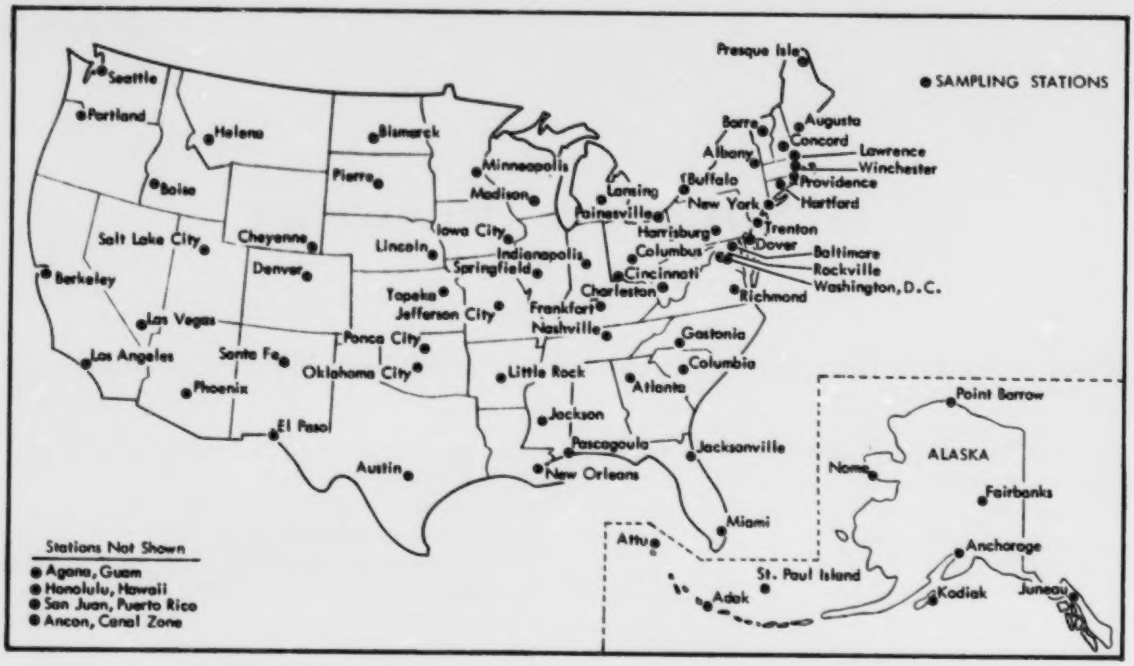

● SAMPLING STATIONS
Seattle
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
Presque Isle
Barre
Augusta
Albany
Concord
Lawrence
Winchester
Providence
New York
Hartford
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Columbus
Cincinnati
Charleston
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Gastonia
Columbia
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Atlanta
Phoenix
Jackson
El Paso
Pascagoula
Jacksonville
Austin
New Orleans
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, SEPTEMBER 1963

data are presented with Canadian and Mexican air data in the form of isogram lines in figure 6.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels each having a collection area of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta concentration of precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm for the individual sample. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The September 1963 average concentrations and total depositions are given in table 2.

Profiles

The profiles of the monthly average fission product beta activity of airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *Radiological Health Data*. In recent issues, several profiles have been updated each month. The last column of table 1 gives the issue having the most recent profile for each station. Seven profiles are updated in figure 2.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, SEPTEMBER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average[a]	Last profile in RHD
Alaska:	Adak	28	2.7	<0.10	0.70	Nov. 1963
	Anchorage	27	4.3	0.15	1.0	Jul. 1963
	Attu	30	2.6	<0.10	1.1	Dec. 1963
	Fairbanks	29	5.6	0.16	1.7	Aug. 1963
	Juneau	21	2.9	0.17	0.70	Sep. 1963
	Kodiak	21	2.1	<0.10	0.62	Oct. 1963
	Nome	0	—	—	—	Feb. 1963
	Point Barrow	30	3.4	<0.10	1.2	Jan. 1964
	St. Paul Island	24	2.1	<0.10	0.71	Apr. 1963
Ariz:	Phoenix	29	3.8	0.40	1.3	Sep. 1963
Ark:	Little Rock	29	4.0	0.42	1.9	Sep. 1963
Calif:	Berkeley	27	2.4	0.25	1.2	Oct. 1963
	Los Angeles	18	3.4	0.68	2.4	Feb. 1963
Canal Zone	Ancon	14	0.22	<0.10	<0.12	[b]
Colo:	Denver	28	4.2	0.21	2.1	Nov. 1963
Conn:	Hartford	29	4.0	0.39	2.2	Oct. 1963
Del:	Dover	16	4.5	0.11	2.9	Aug. 1963
D.C:	Washington	29	4.4	0.67	2.5	Mar. 1963
Fla:	Jacksonville	28	2.6	0.14	1.5	Oct. 1963
	Miami	27	1.6	<0.10	0.72	Feb. 1963
Ga:	Atlanta	4	3.3	3.03	3.1	Jul. 1963
Guam:	Agana	26	0.49	<0.10	0.2	Mar. 1963
Hawaii:	Honolulu	28	3.4	<0.10	1.7	Nov. 1962
Idaho:	Boise	29	4.6	0.74	2.6	Dec. 1963
Ill:	Springfield	28	3.4	0.67	1.8	Oct. 1962
Ind:	Indianapolis	29	4.0	0.77	2.2	Jul. 1963
Iowa:	Iowa City	27	3.6	0.44	1.5	Jan. 1964
Kans:	Topeka	28	3.6	0.71	1.7	Jul. 1963
Ky:	Frankfort	26	7.4	0.34	2.4	Mar. 1963
La:	New Orleans	29	2.7	0.28	1.5	Nov. 1962
Maine:	Augusta	29	4.9	0.16	2.4	Mar. 1963
	Presque Isle	23	3.3	0.16	1.7	Nov. 1963
Md:	Baltimore	19	3.6	0.55	2.3	Nov. 1963
	Rockville	20	4.3	0.49	2.5	[b]
Mass:	Lawrence	29	5.2	0.25	2.4	Aug. 1963
	Winchester	29	4.5	0.37	2.0	[b]
Mich:	Lansing	29	4.5	0.53	2.3	Apr. 1963
Minn:	Minneapolis	27	3.1	0.47	1.6	Mar. 1963
Miss:	Jackson	26	3.4	0.69	2.0	Mar. 1963
	Pascagoula	1	1.0	0.96	1.0	Dec. 1963
Mo:	Jefferson City	29	3.0	0.55	1.6	Nov. 1963
Mont:	Helena	29	4.4	0.58	2.2	Nov. 1963
Nebr:	Lincoln	15	2.6	0.48	1.5	Apr. 1963
Nev:	Las Vegas	26	8.0	0.88	3.5	Jul. 1963
N.H:	Concord	19	4.6	1.4	2.8	[b]
N.J:	Trenton	29	3.6	0.71	2.1	Oct. 1962
N. Mex:	Santa Fe	21	4.1	0.40	1.5	Dec. 1963
N.Y:	Albany	26	6.2	0.46	2.7	Jul. 1963
	Buffalo	25	6.2	0.62	3.4	Nov. 1963
	New York	13	2.9	0.51	1.7	Dec. 1963
N.C:	Gastonia	26	3.6	0.63	1.9	Jan. 1964
N. Dak:	Bismarck	28	3.3	0.26	1.8	Feb. 1963
Ohio:	Cincinnati	20	3.8	0.83	2.2	Aug. 1963
	Columbus	30	4.1	0.74	2.3	Feb. 1963
	Painesville	30	6.2	0.74	3.1	Oct. 1963
Okla:	Oklahoma City	28	3.0	0.33	1.4	Apr. 1963
	Ponca City	26	1.9	0.13	0.93	Oct. 1963
Ore:	Portland	29	4.3	1.04	2.2	Oct. 1963
Pa:	Harrisburg	26	7.3	0.17	2.6	Jan. 1964
P.R:	San Juan	29	1.0	0.16	0.47	Apr. 1963
R.I:	Providence	27	5.0	0.39	2.3	Jan. 1964
S.C:	Columbia	22	2.6	0.23	1.3	Dec. 1963
S. Dak:	Pierre	29	3.5	0.55	1.5	Sep. 1963
Tenn:	Nashville	12	4.2	1.5	3.2	Jan. 1964
Tex:	Austin	29	3.2	0.29	1.5	Aug. 1963
	El Paso	29	2.9	0.36	1.1	Jan. 1964
Utah:	Salt Lake City	30	5.4	0.51	2.3	Aug. 1963
Vt:	Barre	27	6.4	0.55	3.2	Sep. 1963
Va:	Richmond	28	3.3	0.32	1.7	Sep. 1963
Wash:	Seattle	28	2.0	0.36	1.0	Jul. 1963
W. Va:	Charleston	25	4.9	0.16	1.9	Dec. 1963
Wisc:	Madison	29	4.2	0.48	1.9	Sep. 1963
Wyo:	Cheyenne	29	5.0	<0.10	2.6	Aug. 1963
Network summary		1,818	8.0	<0.10	1.9	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, SEPTEMBER 1963

Station location		Average concentration (pc/liter)	Total deposition (nc/m²)
Alaska:			
	Anchorage	740	16
	Fairbanks	1,400	3.8
	Juneau	590	100
Ark:	Little Rock	540	19
Calif:	Berkeley	3,800	12
	Los Angeles	950	3
Colo:	Denver	460	14
Conn:	Hartford	400	36
D.C:	Washington	490	29
Fla:	Jacksonville	480	68
	Miami	[a]<400	<7.4
Ga:	Atlanta	[b]	[b]
Idaho:	Boise	[b]	[b]
Ill:	Springfield	520	6.4
Ind:	Indianapolis	1.200	8.8
Iowa:	Iowa City	480	4.7
Kans:	Topeka	740	12
Ky:	Frankfort	1,200	17
La:	New Orleans	420	95
Maine:	Augusta	640	35
	Presque Isle	630	74
Md:	Baltimore	460	14
Mass:	Lawrence	780	75
	Winchester	1,000	92
Mich:	Lansing	620	26
Minn:	Minneapolis	510	56
Miss:	Jackson	720	5
Mo:	Jefferson City	420	16
Mont:	Helena	1,400	17
Nebr:	Lincoln	<400	<17
Nev:	Las Vegas	610	14
N.J:	Trenton	530	14
N. Mex:	Sante Fe	510	21
N.Y:	Albany	<400	<23
	Buffalo	[b]	[b]
N.C:	Gastonia	400	31
N. Dak:	Bismarck	1,300	24
Ohio:			
	Columbus	600	12
	Painesville	750	17
Okla:	Oklahoma City	<400	[c]
	Ponca City	<420	<43
Ore.	Portland	420	10
Pa:	Harrisburg	480	27
P.R:	San Juan	<400	<78
R.I:	Providence	540	55
S.C:	Columbia	440	53
S. Dak:	Pierre	520	28
Tenn:	Nashville	720	19
Tex:	Austin	410	7
	El Paso	400	5
Utah:	Salt Lake City	510	22
Vt:	Barre	1,100	30
Va:	Richmond	<400	<28
Wash:	Seattle	1,200	18
W. Va:	Charleston	490	16
Wisc:	Madison	490	40
Wyo:	Cheyenne	430	24

[a] The minimum concentration reported is 400 pc/liter.

[b] No evaporated sample received.

[c] Data not available.

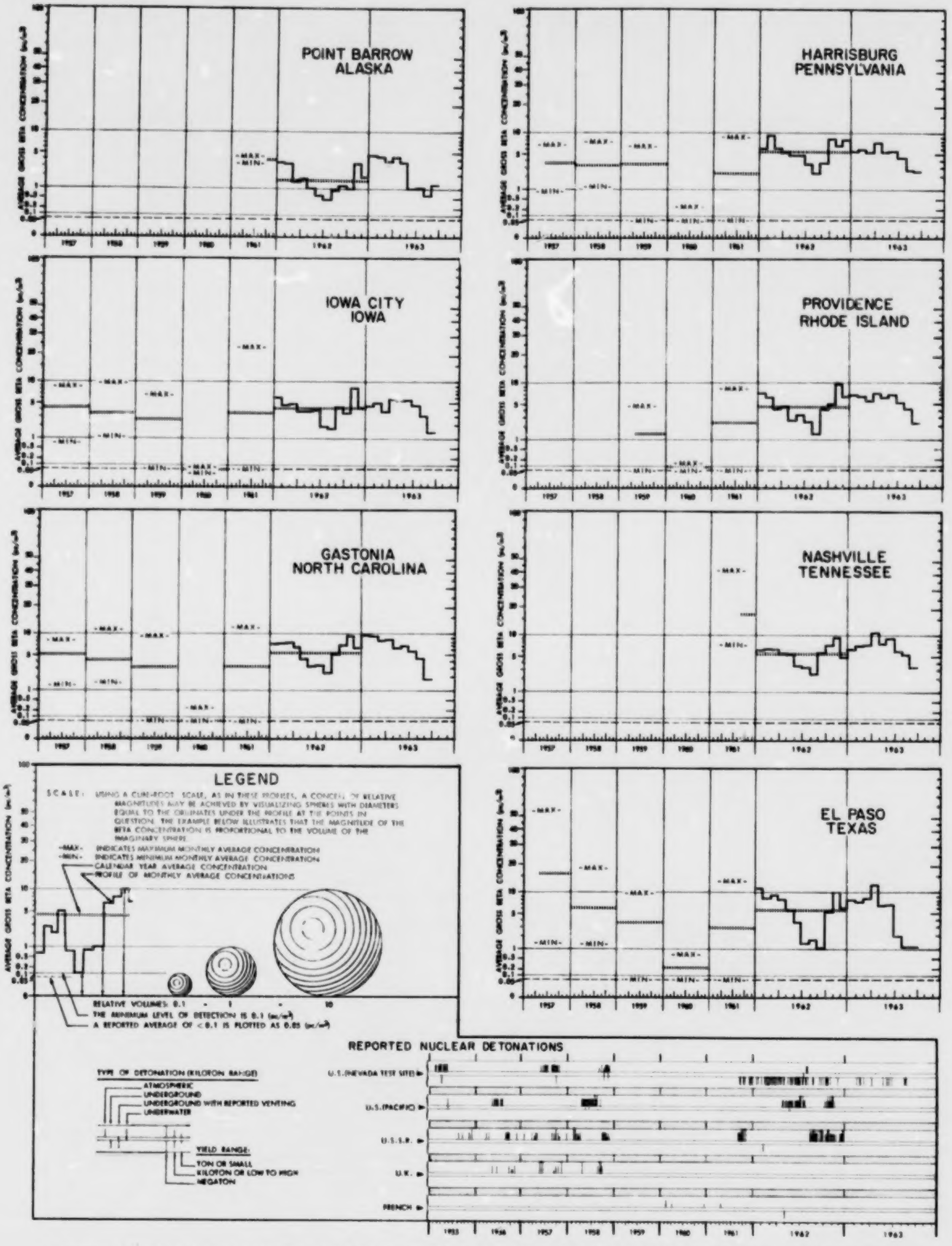


Figure 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR—RADIATION SURVEILLANCE NETWORK, 1957–SEPTEMBER 1963

2. NATIONAL AIR SAMPLING NETWORK, THIRD QUARTER 1963

Division of Air Pollution,
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and certain metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in the NASN Network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. Third quarter 1963 data appear in table 3.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Re-

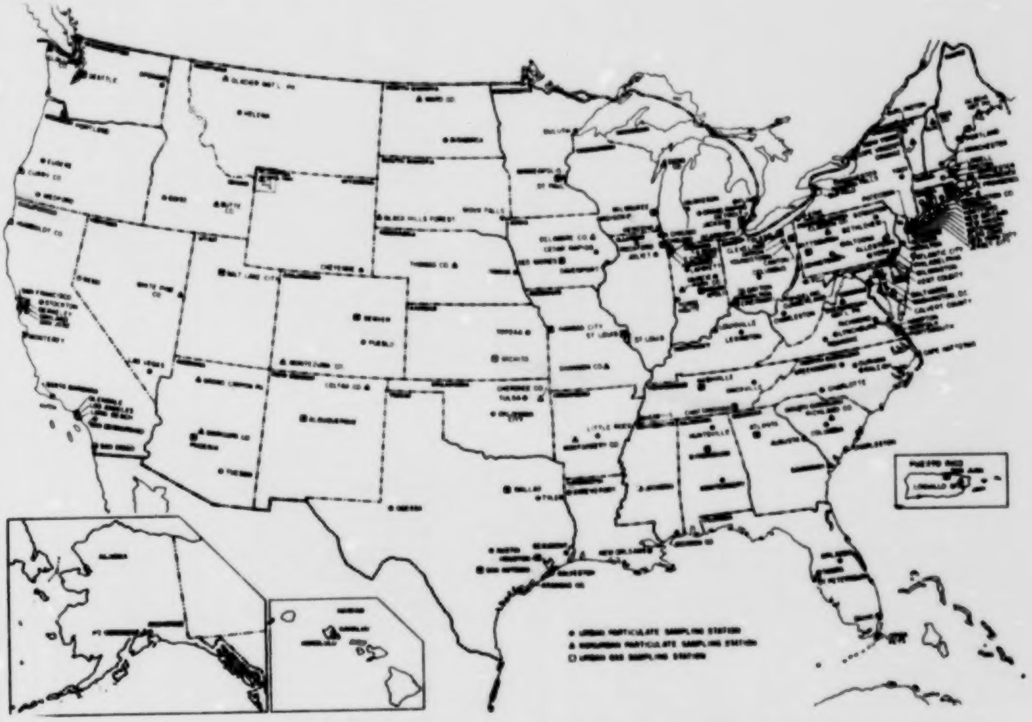

● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
○ URBAN GAS SAMPLING STATION

FIGURE 3.—NATIONAL AIR SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR—NASN, THIRD QUARTER, 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	7	10.0	0.2	3.5
	Huntsville	6	10.5	3.2	7.5
	Montgomery	7	5.2	1.4	3.4
Alaska:	Anchorage	7	7.7	0.4	2.7
	Pt. Woronzof[a]	7	7.6	0.3	3.8
Ariz:	Grand Canyon Pk.[a]	7	10.3	1.1	3.7
	Maricopa County[a]	7	9.6	0.9	3.1
	Phoenix	7	9.0	0.8	2.9
	Tucson	6	7.2	0.7	2.6
Ark:	Little Rock	5	7.9	2.3	4.5
	Montgomery Co.[a]	7	4.3	2.0	3.3
Calif:	Berkeley	6	3.8	1.6	3.0
	Glendale	7	6.7	1.6	3.7
	Humboldt County[a]	5	4.5	0.3	2.3
	Long Beach	5	8.2	2.0	4.3
	Los Angeles	7	7.9	2.7	4.1
	Monterey	6	4.5	1.7	3.1
	Oakland	7	5.1	1.4	3.5
	San Bernardino	5	9.9	2.4	5.8
	San Diego	7	9.2	2.1	4.6
	San Francisco	7	3.9	1.6	3.0
	San Jose	6	4.8	2.1	3.8
	Santa Barbara	7	7.7	2.3	3.8
	Stockton	7	10.8	1.8	5.2
Colo:	Denver	7	10.0	1.8	4.6
	Montezuma County[a]	7	5.0	1.1	3.0
	Pueblo	6	7.0	2.5	4.3
Conn:	Hartford	7	7.8	0.8	4.4
	New Britain	7	7.3	0.8	4.2
	New Haven	7	5.5	1.4	3.2
	Norwich	7	10.2	1.0	5.5
	Waterbury	6	7.2	0.7	3.7
Del:	Kent County[a]	4	7.4	2.3	5.0
	Wilmington	6	8.8	1.5	4.5
D.C:	Washington	6	7.7	2.6	4.9
Fla:	Florida Keys[a]	7	9.6	0.4	4.8
	Miami	5	8.5	1.2	4.4
	Orlando	6	4.4	0.4	3.1
	St. Petersburg	7	6.3	1.0	4.1
	Tampa	6	6.2	0.7	3.9
Ga:	Atlanta	6	4.4	0.1	2.7
	Augusta	7	4.6	3.2	3.7
	Savannah	7	4.6	0.7	3.3
Hawaii:	Honolulu	7	3.3	1.8	2.5
	Kahaiuu[a]	7	4.5	1.4	2.9
Idaho:	Boise	5	18.2	3.6	9.8
	Butte County[a]	7	18.9	2.1	10.7
Ill:	Chicago	5	6.6	1.5	4.4
	East St. Louis	7	28.5	1.8	8.3
	Joliet	7	9.5	2.3	5.3
	North Chicago	6	12.4	1.6	7.7
	Rockford	7	10.6	2.2	6.3
Ind:	East Chicago	6	10.0	1.3	4.1
	Hammond	7	9.8	1.9	5.6
	Indianapolis	6	12.1	2.5	6.4
	Muncie	7	11.9	2.9	5.3
	Parke County[a]	6	11.4	1.1	5.3
	South Bend	7	11.7	1.9	5.8
	Terre Haute	6	11.3	2.4	6.7
Iowa:	Cedar Rapids	7	9.0	2.6	5.7
	Davenport	7	6.6	1.0	3.2
	Delaware County[a]	7	8.5	2.0	5.6
	Des Moines	7	7.8	1.6	4.9
Kans:	Topeka	7	7.6	1.5	3.7
	Wichita	7	8.7	1.7	4.2
Ky:	Lexington	7	13.8	1.5	5.1
	Louisville	4	11.2	2.9	5.4
La:	New Orleans	6	5.0	1.8	3.4
	Shreveport	6	11.1	1.5	4.1
Maine:	Acadia Nat'l. Park[a]	6	12.0	1.9	4.2
	Portland	6	6.5	1.5	3.1
Md:	Baltimore	7	9.3	2.6	4.8
	Calvert County[a]	7	14.6	3.0	5.8
	Cumberland	7	9.9	2.2	4.9
Mass:	Boston	6	13.2	3.7	5.3
	Lowell	7	16.5	1.4	7.4
	Worcester	7	9.2	0.6	4.9
Mich:	Dearborn	6	11.8	2.0	6.6
	Detroit	7	10.6	1.0	5.2
	Flint	6	17.8	1.6	6.8
	Grand Rapids	6	10.6	2.2	5.8
	Jackson	7	13.6	1.5	5.9
	Muskegon	7	8.7	1.4	4.7
Minn:	Duluth	7	8.1	0.9	5.0
	Minneapolis	7	9.7	1.0	5.2
	St. Paul	7	11.5	1.3	6.1
Miss:	Jackson	5	8.6	2.7	5.3
	Jackson County[a]	6	10.7	1.1	4.0
Mo:	Kansas City	6	9.2	0.7	4.8
	Shannon County[a]	5	9.1	1.3	4.0
	St. Louis	6	8.6	2.6	5.1
Mont:	Glacier Nat'l. Park[a]	6	10.0	2.4	5.8
	Helena	7	13.2	2.9	7.7
Nebr:	Omaha	6	13.3	2.6	6.4
	Thomas County[a]	7	13.3	1.5	5.8
Nev:	Las Vegas	6	8.7	1.0	4.0
	Reno	7	14.6	1.6	9.0
	White Pine County[a]	5	8.8	1.1	3.7
N.H:	Coos County[a]	4	13.1	3.4	9.5
N.J:	Atlantic City	7	9.6	2.1	4.9
	Bayonne	6	8.7	2.3	4.3
	Hamilton	6	9.3	2.7	5.1
	Jersey City	7	4.7	2.6	3.4
	Newark	7	9.3	2.2	4.1
	Paterson	6	8.3	2.2	4.3
N. Mex:	Albuquerque	6	4.1	0.8	2.5
	Colfax County[a]	5	4.6	1.8	2.7
N.Y:	Cape Vincent[a]	7	11.3	1.0	4.7
	Massena	7	13.1	1.1	5.2
	New York	7	7.6	2.4	4.5
	Niagara Falls	7	10.7	1.1	5.1
	Rochester	7	10.4	1.0	4.5
	Troy	4	1.8	0.2	1.1
N.C:	Cape Hatteras[a]	6	8.8	1.7	4.9
	Charlotte	7	8.4	3.5	5.7
	Durham	7	13.8	0.4	5.1
	Greensboro	7	10.4	1.8	5.1
	Raleigh	6	9.7	1.5	4.8
N. Dak:	Bismarck	7	10.8	1.9	5.9
	Ward County[a]	6	11.4	1.3	5.9
Ohio:	Akron	7	10.3	1.1	5.2
	Canton	7	10.9	1.3	5.9
	Cincinnati	7	13.1	1.9	6.0
	Cleveland	6	10.0	1.7	5.2
	Columbus	7	11.2	2.2	5.4
	Dayton	7	12.2	2.5	6.0
	Hamilton	7	13.3	2.3	6.0
	Toledo	7	12.0	1.6	5.5
	Youngstown	7	10.3	1.3	5.1
Okla:	Cherokee County[a]	6	5.7	2.2	3.5
	Oklahoma City	6	6.9	1.9	3.9
	Tulsa	7	11.1	1.6	4.1
Ore:	Curry County[a]	7	5.2	0.5	2.0
	Eugene	5	5.1	1.4	3.1
	Medford	6	5.6	2.2	3.6
	Portland	4	5.5	1.0	2.9
Pa:	Allentown	6	5.6	1.6	3.5
	Altoona	6	11.7	2.8	5.8
	Bethlehem	7	9.7	3.6	7.4
	Clarion County[a]	6	8.1	2.0	4.7
	Erie	6	9.5	3.1	5.2
	Johnstown	6	8.6	2.1	5.7
	Philadelphia	6	8.5	1.6	5.0
	Pittsburgh	7	11.1	2.1	5.7
	Scranton	7	6.7	1.3	3.8
	York	7	12.3	2.7	6.8
R.I:	East Providence	6	8.6	1.8	5.1
	Providence	5	9.2	2.7	5.3
	Washington Co.[a]	7	8.1	1.0	4.7
S.C:	Charleston	6	10.2	2.1	5.9
	Columbia	6	5.4	1.3	3.5
	Richland County[a]	5	8.9	2.3	5.3
S. Dak.	Black Hills[a]	6	12.4	2.5	6.7
	Sioux Falls	7	11.5	1.4	5.6
Tenn:	Chattanooga	7	8.3	2.2	4.5
	Knoxville	7	7.1	1.6	4.3
	Memphis	6	6.6	1.5	4.2
	Nashville	7	8.6	1.5	4.3
Tex:	Aransas County[a]	6	3.9	1.1	2.6
	Austin	7	5.0	1.9	3.2
	Beaumont	6	8.9	1.1	4.1
	Dallas	6	7.0	1.1	3.7
	Galveston	7	4.5	1.2	2.8
	Houston	5	5.1	2.0	3.8
	Odessa	6	4.6	1.6	3.2
	San Antonio	4	4.9	2.2	3.0
	Tyler	7	7.6	2.5	3.8
Utah:	Salt Lake City	6	10.1	1.4	4.1
Vt:	Burlington	4	8.7	0.1	3.6
	Orange County[a]	7	13.1	1.5	4.5
Va:	Hampton	7	9.7	1.2	4.2
	Lynchburg	6	6.4	3.4	4.4
	Norfolk	6	6.8	2.5	4.5
	Portsmouth	7	8.5	2.3	4.1
	Richmond	6	5.4	1.8	4.1
	Roanoke	5	12.3	2.1	6.1
	Shenandoah Park[a]	7	10.8	1.7	5.4
Wash:	Clallam County[a]	4	6.8	2.4	4.5
	Seattle	7	3.0	0.7	2.2
	Spokane	7	11.2	2.9	5.8
W. Va:	Charleston	7	8.9	1.1	4.4
	Wheeling	4	14.6	1.4	9.6
Wis:	Door County[a]	5	10.4	2.3	7.2
	Kenosha	7	9.8	1.5	5.4
	Madison	7	9.8	1.6	5.9
	Milwaukee	7	11.1	1.1	5.9
Wyo:	Cheyenne	7	10.0	2.0	5.1
	Yellowstone Park[a]	7	17.4	1.9	8.4
Network summary		1,194	28.5	0.1	4.8

[a] Nonurban station.

TABLE 4.—FISSION PRODUCT BETA ACTIVITY IN PRECIPITATION—NASN, THIRD QUARTER 1963

Station		July		August		September	
		pc/liter	nc/m^2	pc/liter	nc/m^2	pc/liter	nc/m^2
Ala:	Montgomery	1090	88	—	—	180	12
Fla:	Tampa	550	75	500	82	130	11
Ill:	Chicago (Midway)	600	81	1000	60	780	33
	Chicago (O'Hare)	330	32	—	—	250	17
La:	Lake Charles	650	77	550	25	140	25
Maine:	Caribou	1240	113	680	97	380	26
Mass:	Nantucket	940	57	670	76	220	34
Mich:	Sault Ste. Marie	1720	83	1220	126	330	23
Minn:	St. Cloud	430	22	720	104	290	25
Mo:	Columbia	610	44	420	44	—	—
Mont:	Glasgow	—	—	760	46	—	—
Nebr:	Grand Island	350	24	580	49	—	—
N. Y:	Albany	—	—	1850	88	190	12
N. C:	Hatteras	1550	67	620	33	210	10
Ohio:	Cincinnati (Airport)	580	54	—	—	—	—
	Cincinnati (Gest St.)	—	—	940	64	—	—
Pa:	Philadelphia	2610	167	910	70	340	54
	Charleston	720	131	740	109	340	19
	Greenville	840	52	—	—	60	7
Tenn:	Nashville	550	55	320	50	180	15
Tex:	Amarillo	—	—	250	18	—	—
	Brownsville	—	—	—	—	190	17
Va:	Sterling	—	—	530	64	150	11
Wash:	Tatoosh	2520	113	—	—	—	—

search Station in Cincinnati, Ohio, and the National Air Sampling Network. Monthly composite samples of precipitation are collected at 29 stations, which are located at Weather Bureau offices or airports. They are then forwarded to the network laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the third quarter 1963 are presented in table 4.

3. CANADIAN AIR MONITORING PROGRAM,[1] SEPTEMBER 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four RFSP collection stations are located at airports (see figure 4) where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of shortlived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for September 1963 are given in table 5 and presented in conjunction with U. S. and Mexican air data by an isogram map (figure 6).

---

[1] Data from *Radiation Protection Programs*, Vol. 1, No. 10:25–31, Radiation Protection Division, Canadian Department of National Health and Welfare, (October 1963).

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, CANADA, SEPTEMBER 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	29	4.3	0.1	2.5
Coral Harbour	30	4.4	0.1	1.2
Edmonton	30	3.8	0.1	2.0
Ft. Churchill	29	3.6	0.2	1.6
Ft. William	30	4.9	0.1	1.9
Fredericton	30	4.7	0.1	2.2
Goose Bay	29	4.6	0.1	2.0
Halifax	25	5.7	0.0	2.4
Inuvik	30	4.6	0.4	1.9
Montreal	29	6.7	0.7	3.3
Moosonee	30	8.1	0.2	2.2
Ottawa	29	5.5	0.4	3.2
Quebec	29	5.1	0.6	2.7
Regina	30	8.0	0.1	2.3
Resolute	30	3.8	0.2	1.2
St. John's, Nfld	29	3.8	0.2	1.9
Saskatoon	30	6.4	0.1	2.3
Sault Ste. Marie	30	5.9	0.1	2.5
Toronto	29	3.6	0.5	1.4
Vancouver	29	3.5	0.8	1.7
Whitehorse	30	5.3	0.1	1.2
Windsor	30	6.2	0.8	3.1
Winnipeg	30	5.2	0.1	2.0
Yellowknife	30	4.8	0.1	1.7
Network summary	706	8.1	0.0	2.1

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container the polythylene liner is removed, packed with the sample, and sent to the laboratory. Gross beta in precipitation for stations in Canada are presented in table 6. Radionuclide analyses of these samples are given in table 1, page 17.

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA SEPTEMBER 1963

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	465	23.5
Coral Harbour	1203	31.8
Edmonton	878	29.4
Ft. Churchill	880	76.6
Ft. William	1150	76.8
Fredericton	405	50.6
Goose Bay	690	75.8
Halifax	243	44.0
Inuvik	4375	14.4
Montreal	761	89.8
Moosonee	1187	68.1
Ottawa	736	84.3
Quebec	600	75.5
Regina	1708	29.5
Resolute	442	87.0
St. John's, Nfld.	539	60.3
Saskatoon	1592	52.1
Sault Ste. Marie	657	48.2
Toronto	1153	30.5
Vancouver	1620	62.1
Whitehorse	674	43.5
Windsor	674	28.9
Winnepeg	3235	51.7
Yellowknife	1644	34.6
Average	1146	50.8

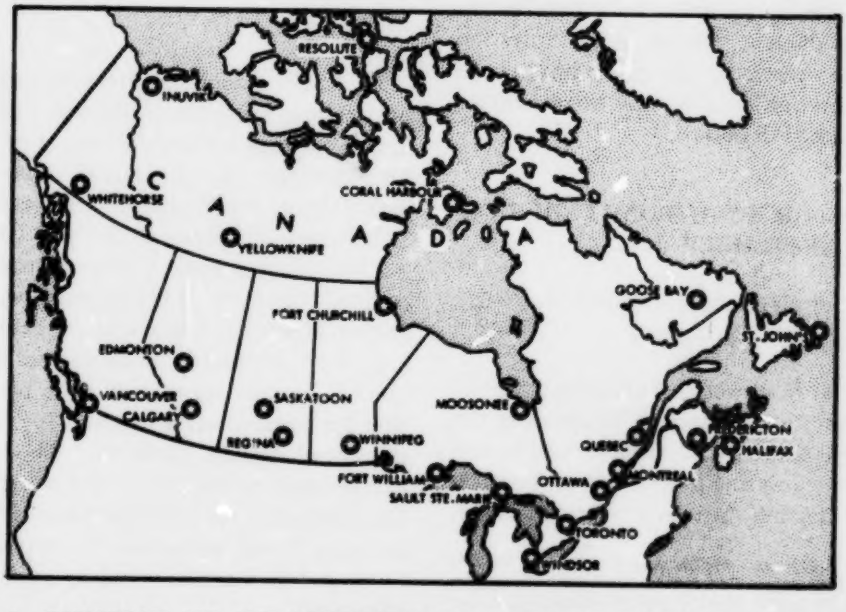

RESOLUTE
INUVIK
C
WHITEHORSE
A
N
A
D
A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
OTTAWA
MONTREAL
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, SEPTEMBER 1963

4. MEXICAN AIR MONITORING PROGRAM, SEPTEMBER 1963

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961 to provide a means for determining increased levels of radioactivity in air and precipitation.

Prior to the establishment of the network, two pilot sampling stations were set up (in Mexico City and San Luis Potosí) to aid in the selection of equipment and sampling sites. Since April 1962 the network has been gradually expanded to 17 stations with the recent addition of stations at Guaymas and Mazatlan (see figure 5). Twelve of the 17 stations are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 × 8 inch glass fiber filter, using high volume samplers. After each 24-hour period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva," CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during September are presented in table 7.

TABLE 7.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, SEPTEMBER 1963

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	6	0.2	0.1	0.2
Ciudad Juárez	15	2.0	0.3	0.8
Chihuahua	10	3.5	0.1	0.9
Ensenada	10	3.1	1.1	1.7
Guadalajara	9	1.0	0.2	0.4
Guaymas	21	3.6	0.4	1.4
La Paz	11	3.4	0.5	1.6
Matamoros	16	2.6	0.1	1.1
Mazátlan	15	1.1	0.2	0.5
Mérida	6	1.8	0.2	0.7
México, D. F.[a]	19	1.7	0.1	0.5
Nuevo Laredo	8	2.4	1.0	1.7
San Luis Potosí	18	3.6	0.4	1.6
Tampico	15	3.7	0.2	1.3
Torreón	12	3.8	0.6	1.7
Tuxtla Gutiérrez[b]	0			
Veracruz	19	2.3	0.2	0.7
Network summary	205	3.8	0.1	1.0

[a] Mexico City
[b] Temporarily shut down

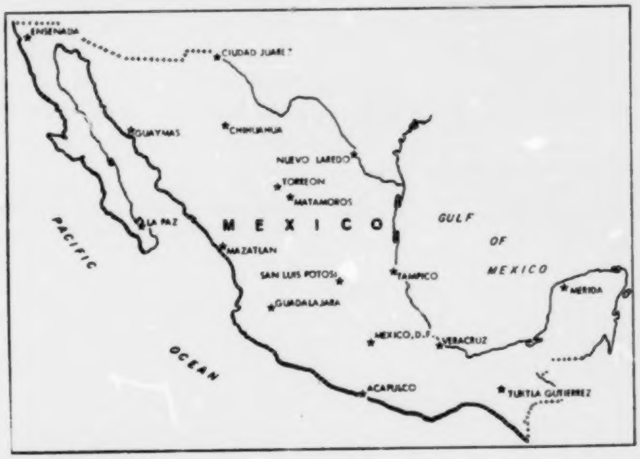


FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

5. PAN AMERICAN AIR SAMPLING PROGRAM, SEPTEMBER 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas to develop their own radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station was activated in November 1962 and the other two stations began air monitoring in December of the same year.

The September 1963 air monitoring results from the three participating countries are given in table 8. The Caracas station is shown on the gross beta concentration isogram map (figure 6). The average concentration at this station adjusted by the RSN intercalibration factor of 1.28 is <0.17 pc/m^3, considerably below the lowest isogram line used on the map (1 pc/m^3).

TABLE 8.—GROSS BETA ACTIVITY IN AIR, SEPTEMBER 1963

[Concentrations in pc/m^3]

Sampling Stations	No. of samples	Maximum	Minimum	Average[a]
Caracas, Venezuela	21	0.29	<0.10	<0.13
Lima, Peru	13	0.19	<0.10	<0.11
Santiago, Chile	12	0.43	<0.10	<0.19

[a] The monthly average is calculated by weighting the individual samples with lengths of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

6. GROSS BETA ACTIVITY IN AIR, NORTH AMERICA, SEPTEMBER 1963

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[1] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Network. The results of this filter study have been published elsewhere (*9*) and are summarized on pages 12–15. The new intercalibration reflects changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are therefore not the same as were previously used.

Figure 6 shows the average gross beta activity in air throughout North America for September 1963. Based on the new intercalibration and setting the Canadian factor at 1.00, the Mexican data were multiplied by 0.81 and the RSN data were adjusted by a factor of 1.28.

---

[1] The January to August 1963 isogram maps were published in the May to December 1963 *Radiological Health Data*, respectively.

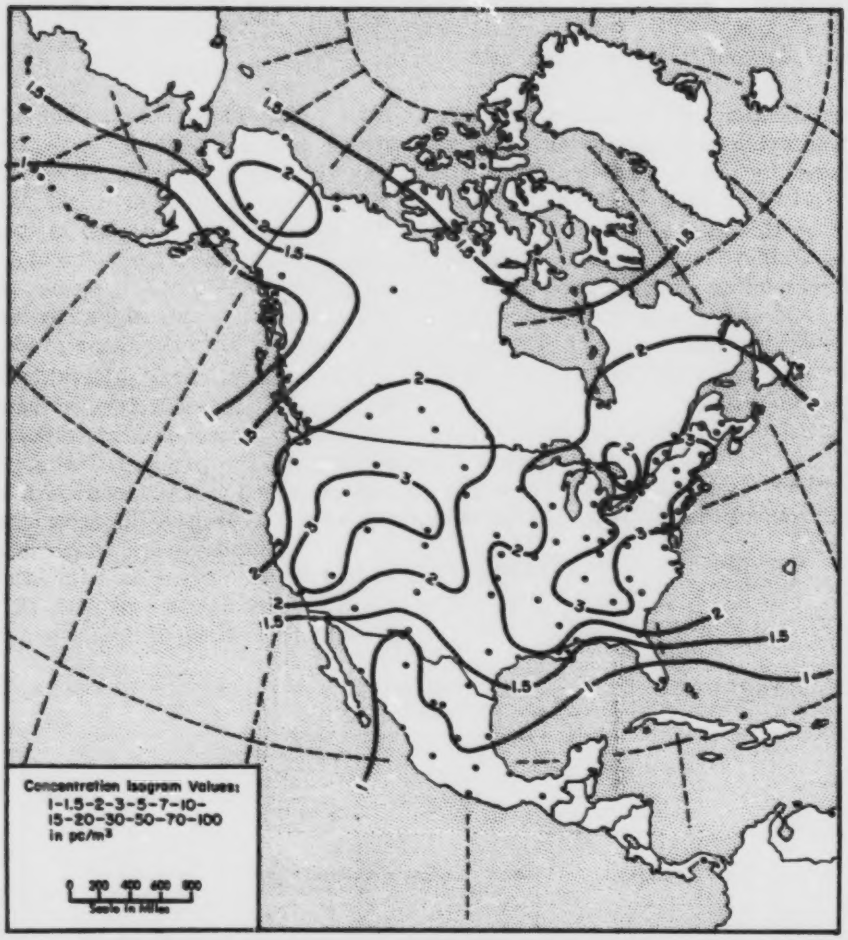


FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, SEPTEMBER 1963

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73*: 1318–30 (June 1, 1948).

(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D.C. 20201 (Distribution by official request).

(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) Beale, J. and J. Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD–11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*8*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D.C. (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(*9*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in Radiological Health Data, January 1964.

Intercalibration of The Major North American Air Monitoring Systems[1]

L. B. Lockhart, Jr. and R. L. Patterson, Jr.[2]

An intercalibration of some systems employed in monitoring airborne fission products was undertaken by the U. S. Naval Research Laboratory (NRL) in 1962 (*1*). The information supplied by this intercalibration proved of utility to the Public Health Service in its reporting and correlating of data supplied by the various air monitoring networks. In particular it made possible the construction of reasonably accurate contour maps of radioactivity over the United States and Canada.

At the request of the Comision Nacional de Energia Nuclear of Mexico (Laboratorio de Desechos Radiactivos) and the Public Health Service (Radiological Health Data and Reports Staff), NRL undertook another intercalibration which was extended to cover the five major radioactivity monitoring networks operating in North America. The networks participating in this program are identified in table 1; also included in this table are some of the characteristics of the various systems used by these organizations to collect and measure the concentration of airborne fisson products.

Fundamentally, the intercalibration involved the side-by-side collection of samples at this laboratory for subsequent evaluation of radioactivity by the participating organizations by their customary procedures. All samples were collected on positive-displacement blowers of similar characteristics which had been calibrated for air flow against the same flow meter. Each filter thus was presumed to have sampled a measured volume of the same air mass.

TABLE 1.—CHARACTERISTICS OF THE AIR MONITORING SYSTEMS COMPARED IN THE INTERCALIBRATION PROGRAM

System Elements	Radiological Protection Program, National Commission of Nuclear Energy, Mexico	Radiation Protection Division, Canadian Dept. of Health and Welfare	80th Meridian (West) Sampling Program, USAEC, Health and Safety Laboratory	National Air Sampling Network, Public Health Service	Radiation Surveillance Network, Public Health Service
Air Sampler					
Blower type	Centrifugal	Positive displacement	Positive displacement	Centrifugal	Centrifugal
capacity[a]	1800-2000 m^3/day (STP)	650 m^3/day	1200 m^3/day	2200 m^3/day	2000 m^3/day
Motor, type	Free-running	Constant speed	Constant speed	Free-running	Free-running
Filter, type	Glass fiber	Glass fiber	Polystyrene	Glass fiber	Cellulose, carbon loaded
designation	Staplex TFA-69 GF	Hurlburt 934AH	Microsorban	MSA-1106BH	MSA BM-2133 (CR-17651)
size	6 x 9 inches	4 inch dia.	8 inch dia.	8 x 10 inches	4 inch dia.
effective area	41.3 sq. inches	9.3 sq. inches	41.7 sq. in.	63.0 sq. in.	9.6 sq. in.
Volume measurement (at field stations)	Orifice plate and gage	Prior calibration	Pressure gage and prior calibration	Orifice plate and gage	Orifice plate and gage
Sample processing	1⅛" disc removed for counting	2" disc removed for counting	γ-counted in plastic envelope	Effective area counted 41.9 sq. in.	Counted in glassine envelope
Counting procedure					
Counter, type-size (dia.)	Gas flow Geiger-Mueller	Gas flow Geiger-Mueller-2 inch	10 x 20 cm NaI crystal	Gas flow proportional-7½ in.	Gas flow proportional-7⅛ in.
window thickness	0.15 mg/cm^2	0.8 mg/cm^2	(not applicable)	0.9 mg/cm^2	4.5 mg/cm^2
geometry	2π	2π	2π	2π	2π
background	2 c/m	13 c/m	1000 c/m	300 c/m	600 c/m
Counting time	Preset count of 1000 or 2000	Preset count of 1000	10 or 20 min.	1 or 2 min.	1 min.
Standard	T1^{204}	Sr^{90} (Y^{90})	Cs^{137}, Ce^{144}, I^{131}, Zr^{95}, Ba^{140}	RaD+E, T1^{204}	Sr^{90} (Y^{90})
Activity recorded	At time of measurement (4-7 days after collection)	Extrapolated to end of collection	At time of measurement; β activity estimated from counts of γ (>1 mev) and γ (total).	Extrapolated to end of collection	Extrapolated to end of collection.

[a] Average capacity in operating system

---

[1] Summary of NRL Report 6025, see reference (*2*).

[2] Dr. Lockhart is Head of the Physical Chemistry Branch, and Mr. Patterson is Head of the Radiochemistry Section, Physical Chemistry Branch, U.S. Naval Research Laboratory, Washington, D.C.

Experimental Procedures

The five air sampling systems were installed in three louvered shelters located on the roof of a building at NRL some 25 feet above the ground. Each of the sampler units employed a filter head either supplied by the participating network or similar to that used by the network. The filter media used in this study were also supplied by the networks from their usual stocks.

Samples were routinely collected over a 24-hour period starting at 3:00 PM (1500) local time, except on weekends when 72-hour collections were made. The sampling phase of this program covered the period May 31–June 24, 1963, a time when there was considerable long-lived fission product radioactivity in the air.

On removal of samples from the collectors, two or more of them were placed in lead-shielded Geiger-Mueller counters and their β-activity followed for a period of 16 hours. Subsequently, the remaining samples were counted and all corrected for the residual natural activity remaining, as estimated from the decay measurements. Counting was performed with the samples enclosed in glassine or plastic envelopes to prevent contamination or loss of activity from the filter by handling. The samples were then forwarded to the parent organizations for measurement.

Results

The preliminary measurements were undertaken at NRL to ascertain if the various samples were truly duplicates. The summary of these measurements in terms of the ratios of activity found on the various filters presented in table 2 indicates that the samples from certain units were biased to some extent; the small variations of single pairs of measurements, however, indicate that each collector was effectively sampling the same air mass. The observed bias appears to be related to filter behavior rather than to the local sampling arrangement, though small differences could be caused by absorption of β activity by the envelopes in which the samples were counted. The Public Health Service Radiation Surveillance Network cellulose filter has been noted previously to be less effective due to lower filter efficiency and greater self-absorption of activity (*1*); the Health and Safety Laboratory filters had visibly uneven deposit of dust and a measurable difference in radioactivity across the surface. Since in these preliminary evaluations only a single measurement was made of a small area in the approximate center of the filter, any persistent variation in activity with location could introduce bias into the results.

TABLE 2.—RELATIVE ACTIVITY OF FILTERS FROM PRELIMINARY EVALUATION AT NRL[a]

Systems Compared	Number of Measurements	Mean of Measured Ratios	Standard Deviation	
			of Mean	of Single Measurement
Relative to PHS-RSN				
Mexico	16	1.26	±0.019	±0.075 (6.0%)
Canada	11	1.22	±0.016	±0.054 (4.4%)
HASL	16	1.09	±0.028	±0.091 (8.3%)
PHS-NASN	16	1.32	±0.019	±0.078 (5.9%)
Relative to PHS-NASN				
Mexico	16	0.95	±0.016	±0.063 (6.6%)
Canada	11	0.91	±0.013	±0.044 (4.9%)
HASL	16	0.83	±0.012	±0.049 (5.9%)
Relative to HASL				
Mexico	16	1.16	±0.026	±0.104 (9.0%)
Canada	11	1.10	±0.021	±0.070 (6.5%)
Mexico/Canada	11	1.03	±0.014	±0.048 (4.6%)

[a] Corrected for relative filter areas.

The fission product radioactivity concentrations reported by the participating organizations for these duplicate samples are reported in table 3. In each case the volume of air sampled is based on the NRL measurement. The ratios of the activity concentrations of samples collected during the same period and evaluated by the different methods are listed in table 4 together with the average ratios and their standard deviations. These ratios are the factors for converting radioactivity concentrations determined by any one system to those of another system. It should be pointed out that these factors do not take into account possible discrepancies in the determination or estimation of the volume of air sampled at the various field installations; moreover, they are based on the counting of samples of old fission debris (minimum age of 5 months), whose β energy distribution is different from that of fresh fission products.

No data have been included for the Canadian filters during the period May 31–June 7 because of a lack of knowledge of the volume of air sampled (which resulted from a slipping V-belt drive on the blower), or for the Mexican filters

TABLE 3.—AIR CONCENTRATIONS OF FISSION PRODUCT RADIOACTIVITY BASED ON ANALYSIS BY THE PARENT ORGANIZATION OF AIR FILTERS EXPOSED IN PARALLEL AT WASHINGTON, D.C.

Collection period (1963)	Activity in picocuries per cubic meter of air				
	Mexico	Canada[1, 2]	PHS-RSN[1]	PHS-NASN[1]	HASL
May 31–June 3	7.23	—	4.58	7.8	5.99
June 3–4	1.45	—	0.82	1.36	0.96
4–5	10.30	—	7.74	13.0	9.32
5–6	7.32	—	4.73	8.1	5.49
6–7	9.63	—	6.08	10.7	7.38
June 7–10	5.73	4.14	3.72	6.6	4.86
10–11	16.10	12.83	10.11	19.4	14.27
11–12	11.84	8.64	7.29	13.7	9.86
12–13	7.02	5.09	4.33	7.9	5.81
13–14	—	11.52	8.01	13.5	9.32
June 14–17	—	7.97	8.34	14.9	11.03
17–18	—	14.40	10.21	18.7	13.77
18–19	—	15.75	10.63	19.5	14.31
19–20	—	11.52	8.57	15.5	12.15
20–21	—	5.72	4.00	6.7	4.86
June 21–24	—	10.89	8.65	15.9	11.70

[1] Activity extrapolated to time of collection.
[2] Based on new standardization effective September 1, 1963.

TABLE 4.—ACTIVITY CONCENTRATION RATIOS OF PARALLEL SAMPLES EVALUATED BY THE VARIOUS PARTICIPATING ORGANIZATIONS

Comparative Radioactivity Results	Number of Measurements	Mean of Measured Ratios	Standard Deviation	
			of Mean	of Single Comparison
I. Relative to PHS-RSN				
a. Mexico	9	1.58	±0.038	±0.114 (7.2%)
b. Canada	11	1.28	±0.049	±0.161 (12.6%)
c. HASL	16	1.29	±0.022	±0.088 (6.8%)
d. PHS-NASN	16	1.77	±0.020	±0.080 (4.5%)
II. Relative to PHS-NASN				
a. Mexico	9	0.89	±0.026	±0.078 (8.8%)
b. Canada	11	0.71	±0.031	±0.104 (14.6%)
c. HASL	16	0.73	±0.007	±0.027 (3.7%)
III. Relative to HASL				
a. Mexico	9	1.24	±0.041	±0.123 (9.9%)
b. Canada	11	0.97	±0.047	±0.155 (16.0%)
IV. Other				
a. Mexico/Canada	4	1.34	±0.032	±0.063 (4.7%)

during the period June 13–24, when their radioactivity counting equipment was malfunctioning. However, sufficient information has been obtained during periods when the fission product concentrations varied widely to give statistically significant intercalibration ratios to the counting techniques employed by the various networks.

The activity concentration ratios shown in table 4 relative to the Public Health Service Radiation Surveillance Network (RSN) are as follows: Canada (effective September 1, 1963), 1.28 ± 0.049; Health and Safety Laboratory (HASL), 1.29 ± 0.022; Mexico, 1.58 ± 0.038; and, Public Health Service National Air Sampling Network (NASN), 1.77 ± 0.020. The Canadian value of 1.28 ± 0.049 would have been 1.64 ± 0.063 by the standardization in effect prior to September 1963; this is in reasonable agreement with the value 1.54 ± 0.021 determined in the 1962 intercalibration (*1*).

These activity ratios may also be expressed relative to any of the other networks. Relative to Canada[1] the ratios are: RSN, 0.78; HASL, 1.01; Mexico, 1.23; and NASN, 1.38.[2]

Conclusions

Interconversion factors for comparing the radioactivity concentrations reported by the major air monitoring networks in North America have been derived which are realistic for the various networks as now operated to the extent that the on-site air flow measurements are themselves realistic. The relative activity concentrations reported by the networks are as follows: Public Health Service Radiation Surveillance Network, 0.78; Canadian Radiation Protection Division Network, 1.00; USAEC Health and Safety Laboratory 80th Meridian Network, 1.01; Mexican Radiological Protection Program Network, 1.23; and Public Health Service National Air Sampling Network, 1.38.

---

[1] The values given in *Radiological Health Data*, December 1962 (*1*) were relative to Canada, i.e. setting Canada = 1.00.

[2] Conversion factors, applied to data from the various networks so that they correspond to the Canadian data, are found by taking the reciprocals of the activity ratios. They are as follows: RSN, 1.28; HASL, 0.99; Mexico, 0.81; and NASN, 0.72.

The above factors apply accurately only to a fission product conglomerate which is relatively free of the shorter-lived fission products. The minimum age of any debris that could have been collected during the period of this intercalibration (May 31–June 24) was over five months; however, the average age was considerably longer because of the large quantity of older bomb debris that existed in the stratospheric source of fallout at this time. The β energy distribution of the gross fission products which one might expect to collect in the future in the absence of further atmospheric contamination by nuclear explosions should not be significantly different from that existing at the time of this study.

Acknowledgments

The U. S. Naval Research Laboratory and the authors wish to express their appreciation to the various organizations and persons who have cooperated in this project: Ing. A. P. Baez, Subdirector, Radiological Protection Program, National Commission of Nuclear Energy, Mexico; Dr. A. H. Booth, Senior Scientific Officer, Radiation Protection Division, Department of National Health and Welfare, Canada; Dr. J. H. Harley, Director, and Mr. W. R. Collins, Health and Safety Laboratory, U. S. Atomic Energy Commission; Mr. E. C. Tabor, Chief, Air Quality Section, Division of Air Pollution, Public Health Service; and Mr. D. L. Snow, Chief, and Mr. R. G. Bostrom, Radiological Health Data and Reports Staff, and Mr. C. A. Markarian, Chief, State Surveillance Program, Division of Radiological Health, Public Health Service. Partial financial support was supplied by the Division of Biology and Medicine. U. S. Atomic Energy Commission.

REFERENCES

(*1*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D.C. 20390 (November 1962). Summarized in *Radiological Health Data, 3*: 466–70 (December 1962).

(*2*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D.C. 20390 (December 1963).

17

Fission Product Gamma Activity in Airborne Particulates—80th Meridian, August 1963

Health and Safety Laboratory, AEC

Total gamma activity measurements for weekly ground-level air filter samples taken at 80th Meridian stations (see figure 1) during August 1963 are listed in table 1. Calculated ratios of gamma activity in excess of 1 Mev to total gamma activity are also listed in the table. Average monthly total gamma activity concentrations calculated from the weekly values are plotted in figure 2 as an activity-latitude profile and compared with the profile for the second quarter 1963 average.

Gamma activity results for August show a general decrease in ground-level air concentrations in the Northern Hemisphere but no major change in the Southern Hemisphere levels with respect to results obtained for July 1963. The data show a shift in the Northern Hemisphere air concentration maximum from about latitude 30° to 50°. The average value for the Northern

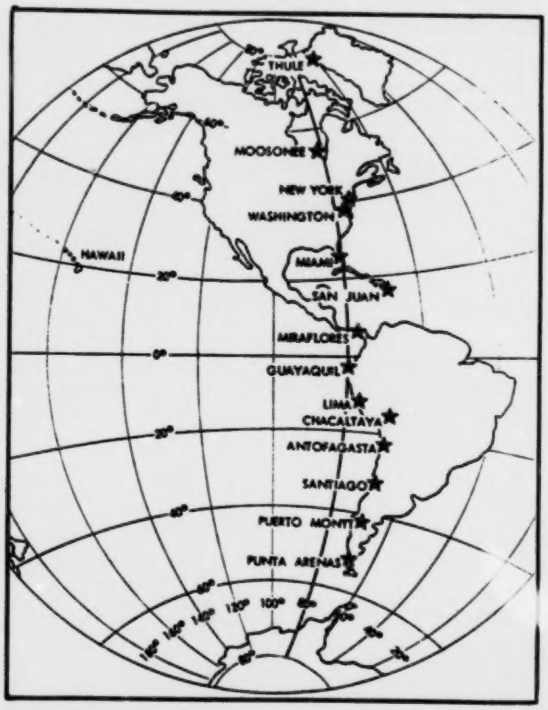


FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, AUGUST 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\frac{(\gamma > 1 \text{ Mev})}{\text{total } \gamma}$
		Filter	Average for month	
Thule	8/1 -8	12.0		0.034
	8/8 -15	1.33		0.034
	8/15-22	2.70		0.035
	8/22-9/1	1.94	4.49	0.035
Moosonee	8/1 -8	4.77		0.054
	8/8 -15	2.14		0.045
	8/15-22	2.22		0.040
	8/22-9/1	1.52	2.66	0.047
New York	8/1 -8	4.14		0.047
	8/8 -15	12.4		0.049
	8/15-22	3.46		0.048
	8/22-9/1	2.54	5.64	0.047
Washington	8/1 -8	5.08		0.035
	8/8 -15	5.46		0.035
	8/15-22	2.49		0.040
	8/22-9/1	2.34	3.84	0.038
Miami	8/1 -8	2.22		0.045
	8/8 -15	1.52		0.039
	8/15-22	0.642		0.047
	8/22-9/1	1.16	1.39	0.039
Mauna Loa	8/1 -8	1.36		0.043
	8/8 -15	0.974		0.044
	8/15-22	1.65		0.045
	8/22-9/1	1.46	1.36	0.048
San Juan	8/1 -8	1.51		0.042
	8/8 -15	0.903		0.038
	8/15-22	0.757		0.036
	8/22-9/1	0.909	1.02	0.046
Miraflores	8/1 -8	0.525		0.049
	8/8 -15	0.616		0.049
	8/15-22	0.491		0.052
	8/22-9/1	0.309	0.485	0.050
Guayaquil	8/1 -8	0.0617		0.043
	8/8 -15	0.0769		0.060
	8/15-22	0.0892		0.052
	8/22-9/1	0.0894	0.0793	0.047
Lima	8/1 -8	0.0697		0.022
	8/8 -15	0.176		0.037
	8/15-22	0.0688		0.031
	8/22-9/1	0.170	0.121	0.045
Chacaltaya	8/1 -8	0.414		0.046
	8/8 -15	0.269		0.041
	8/15-22	0.275		0.050
	8/22-9/1	0.253	0.303	0.043
Antofagasta	8/1 -8	0.0650		0.037
	8/8 -15	0.154		0.048
	8/15-22	0.126		0.053
	8/22-9/1	0.115	0.115	0.048
Santiago	8/1 -8	0.208		0.057
	8/8 -15	0.114		0.048
	8/15-22	0.0825		0.049
	8/22-9/1	0.116	0.130	0.054
Puerto Montt	8/1 -8	0.0303		0.059
	8/8 -15	0.0614		0.039
	8/15-22	0.0299		0.053
	8/22-9/1	0.0348	0.0391	0.054
Punta Arenas	8/1 -8	0.0283		0.050
	8/8 -15	0.0156		0.050
	8/15-22	—		—
	8/22-9/1	0.0277	0.0239	0.040

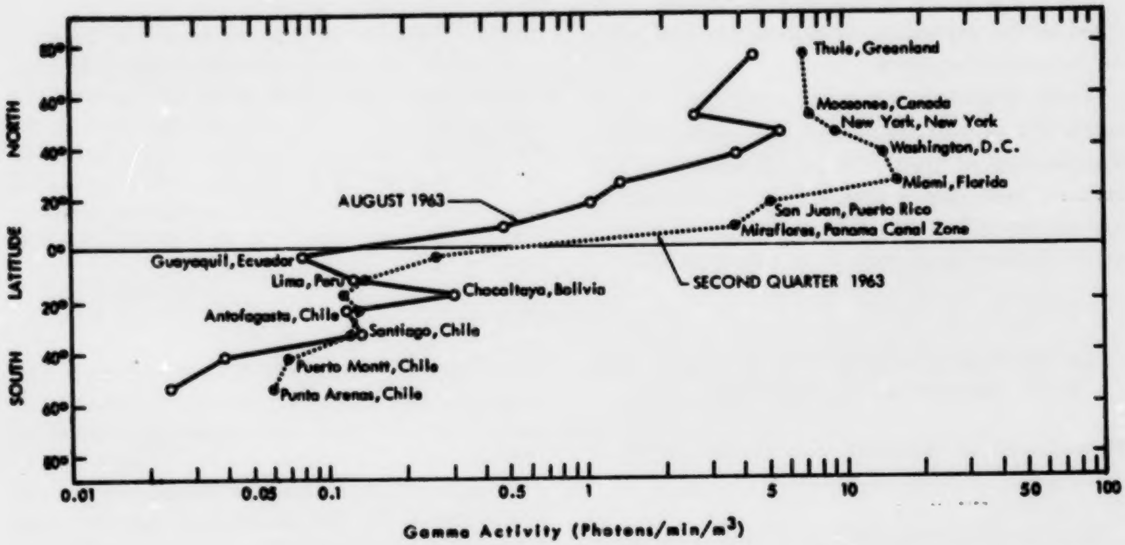


FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, SECOND QUARTER AND AUGUST 1963

Hemisphere was 2.6 $\gamma/\text{min}/\text{m}^3$ (photons per minute per cubic meter) with a range of from 0.49 to 5.6 $\gamma/\text{min}/\text{m}^3$. At the southern hemisphere stations the average concentration was 0.10, with a range of from 0.024 to 0.30 $\gamma/\text{min}/\text{m}^3$.

Total beta activity estimates are not given for the August samples because of the continued appearance of significant concentrations of non-fission produced high-energy gamma emitters.

Recent coverage in *Radiological Health Data*:

Period	Issue
March, and April 1963	*September 1963*
May 1963	*October 1963*
June, and July 1963	*December 1963*

Monthly Deposition of Various Radionuclides

For the purpose of this section, fallout is defined as the deposition of radioactive materials on the earth's surface.

Total fallout is generally considered to be composed of two fractions: that deposited by the settling of particulates, often termed dry fallout, and that contained in precipitation, sometimes called wet fallout or rainout. Normally, fallout is expressed in terms of the activity of selected radionuclides deposited on a unit surface during a given period of time.

Monthly strontium-90 deposition in the United States and other areas during the first and second halves of 1962, as reported by the Health and Safety Laboratory, AEC, appeared in the August and October 1963 issues of *Radiological Health Data*, respectively. Deposition of other radionuclides at four stations was also reported.

FALLOUT MEASUREMENTS IN CANADA,[1] JULY THROUGH SEPTEMBER 1963

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry). The radiochemical analyses of these precipitation or fallout samples for July through September 1963 are given in table 1.

Radiochemical analyses of fallout samples for five stations for the months of October 1962 through April 1963 were included with the tables of gross beta in precipitation in the February through August 1963 issues of *Radiological Health Data*. May and June radiochemical data for the five stations were reported in the October 1963 *RHD*.

---

[1] Data from *Radiation Protection Programs*, Vol. 1, No. 8. p 19; No. 9, p 18; No. 10, p 24, Radiation Protection Division, Canadian Department of National Health and Welfare (Aug.–Oct., 1963).

TABLE 1.—ANALYSIS OF FALLOUT FOR SPECIFIC RADIONUCLIDES, JULY–SEPTEMBER 1963[a]

[nc/m²]

Station	Deposition during July					Deposition during August					Deposition during September				
	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}
Calgary	16.4	5.41	11.2	35.8	0.06	3.96	1.87	3.84	12.10	0.04	0.49	0.40	0.84	1.44	0.031
Coral Harbour	5.24	1.59	2.26	[b]—	—	2.29	1.35	2.22	—	—	0.58	0.46	1.04	—	—
Edmonton	3.74	2.15	1.28	—	—	1.32	0.85	2.47	—	—	0.61	0.58	0.89	—	—
Ft. Churchill	6.06	3.52	4.48	—	—	1.13	0.65	1.11	—	—	1.69	1.06	2.12	—	—
Ft. William	5.45	1.97	2.88	—	—	1.99	0.88	3.90	—	—	1.65	1.32	3.24	—	—
Fredericton	5.75	4.05	6.62	—	—	8.16	3.87	6.58	—	—	1.12	0.87	1.72	—	—
Goose Bay	11.0	3.85	6.75	—	—	[c]	[c]	[c]	[c]	[c]	1.95	1.29	2.33	—	—
Halifax	5.76	1.86	3.80	11.2	0.07	6.25	2.36	4.70	12.0	0.03	1.65	1.20	1.92	5.15	0.008
Inuvik	5.14	2.27	4.27	—	—	2.44	0.97	1.51	—	—	0.30	0.27	0.47	—	—
Montreal	[b]—	—	—	—	—	10.7	4.38	8.35	23.2	0.04	2.72	1.97	3.10	2.79	0.044
Moosonee	4.57	4.31	1.11	—	—	3.67	2.07	2.65	—	—	1.40	0.86	1.99	—	—
Ottawa	9.15	2.96	5.53	—	—	5.86	3.65	6.38	—	—	1.95	1.56	2.72	—	—
Quebec	4.22	1.90	3.48	—	—	6.66	3.58	5.74	—	—	1.52	1.08	2.30	—	—
Regina	14.0	4.20	7.87	—	—	4.31	2.82	4.29	—	—	0.54	0.71	0.88	—	—
Resolute	[c]	[c]	[c]	[c]	[c]	0.38	0.74	0.67	—	—	0.41	0.91	1.45	—	—
St. John's, Nfld.	4.63	1.42	2.26	—	—	4.18	2.15	3.69	—	—	0.94	0.60	1.19	—	—
Saskatoon	14.0	5.00	7.80	—	—	4.37	1.86	4.95	—	—	0.88	0.84	1.56	—	—
Sault Ste. Marie	5.60	2.56	4.86	—	—	4.74	2.90	5.35	—	—	1.39	1.01	1.59	—	—
Toronto	6.78	1.58	1.92	—	—	4.78	1.95	2.39	—	—	0.72	0.46	0.89	—	—
Vancouver	6.01	2.04	2.58	9.50	0.05	1.76	0.92	1.72	4.73	0.05	1.18	0.82	1.71	3.88	0.020
Whitehorse	3.02	1.10	2.31	—	—	1.39	1.15	1.98	—	—	1.43	1.06	1.81	—	—
Windsor	3.00	1.68	3.11	—	—	1.80	1.42	1.72	—	—	0.54	0.45	0.44	—	—
Winnipeg	—	—	—	—	—	4.85	2.56	3.26	9.60	0.07	0.92	0.64	1.32	2.42	0.029
Yellowknife	8.16	2.91	2.49	—	—	4.18	1.65	3.00	—	—	0.79	0.77	1.13	—	—

[a] All values corrected for decay back to end of collection month.
Values for Sr^{90}, Cs^{137} and Zr^{95} do not include the activities of their daughter nuclides, Y^{90}, Ba^{137m} and Nb^{95}.
[b] Dash indicates no analysis.
[c] No sample.

SECTION II.—MILK AND FOOD

Milk Surveillance

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. PASTEURIZED MILK NETWORK, SEPTEMBER 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. More milk sampling points continued to be added until July 1962, when the total number of stations reached 62.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern, Southeastern, or Northeastern Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to the States for possible public health action. Complete analytical results are available 6 to 7 weeks after collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method of compositing specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations, the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's

21

sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, sampling was done twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors in Radionuclide Measurements

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, a two-week composite is analyzed radiochemically for strontium-89 and strontium-90. There is

---

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, SEPTEMBER 1963[a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in RHD
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	
Ala:	Montgomery	1.17	1.15	1.4	1.4	45	25	21	20	85	70	Oct. 63
Alaska:	Palmer	1.17	1.16	1.5	1.6	45	45	24	26	160	165	Nov. 63
Ariz.	Phoenix	1.14	1.12	1.7	1.7	5	<5	3	4	25	30	Jan. 64
Ark:	Little Rock	1.19	1.18	1.3	1.4	105	55	44	42	170	155	Nov. 63
Calif:	Sacramento	1.18	1.16	1.6	1.7	10	5	9	9	50	50	Dec. 63
	San Francisco	1.17	1.16	1.6	1.7	20	15	9	7	65	55	Oct. 63
Colo:	Denver	1.18	1.11	1.6	1.6	40	30	22	20	110	95	Dec. 63
Conn:	Hartford	1.16	1.14	1.6	1.7	40	25	31	24	215	170	Dec. 63
Del:	Wilmington	1.18	1.17	1.6	1.5	35	25	30	27	150	135	Jan. 64
D. C:	Washington	1.13	1.14	1.5	1.5	45	25	21	20	110	80	Oct. 63
Fla:	Tampa	1.19	1.17	1.4	1.4	25	20	14	14	275	290	Jan. 64
Ga:	Atlanta	1.18	1.16	1.4	1.5	75	40	33	29	190	130	Oct. 63
Hawaii:	Honolulu	1.18	1.16	1.6	1.7	15	10	12	12	85	90	Nov. 63
Idaho:	Idaho Falls	1.17	1.16	1.5	1.6	60	20	33	21	160	115	Jan. 64
Ill:	Chicago	1.21	1.18	1.6	1.6	30	20	23	20	125	110	Oct. 63
Ind:	Indianapolis	1.19	1.19	1.6	1.6	40	30	24	20	110	85	Dec. 63
Iowa:	Des Moines	1.15	1.19	1.5	1.6	50	35	28	27	85	85	Jan. 64
Kans:	Wichita	1.16	1.15	1.5	1.6	35	20	24	21	80	75	Nov. 63
Ky:	Louisville	1.14	1.14	1.4	1.5	100	50	39	35	125	80	Jan. 64
La:	New Orleans	1.21	1.20	1.4	1.5	80	50	41	40	160	145	Nov. 63
Maine:	Portland	1.18	1.16	1.6	1.6	55	40	38	36	300	265	Jan. 64
Md:	Baltimore	1.14	1.12	1.4	1.5	60	35	25	22	145	100	Jan. 64
Mass:	Boston	1.18	1.15	1.6	1.6	70	50	47	40	120	290	Oct. 63
Mich.	Detroit	1.17	1.15	1.6	1.6	30	20	22	18	130	130	Dec. 63
	Grand Rapids	1.18	1.17	1.6	1.7	35	25	22	22	145	150	Jan. 64
Minn:	Minneapolis	1.17	1.14	1.5	1.6	70	40	34	30	170	140	Oct. 63
Miss:	Jackson	1.22	1.21	1.4	1.5	80	40	36	34	125	95	Dec. 63
Mo:	Kansas City	1.15	1.16	1.6	1.5	55	55	29	32	75	65	Dec. 63
	St. Louis	1.16	1.17	1.5	1.6	45	25	25	22	85	75	Nov. 63
Mont:	Helena	1.16	1.16	1.4	1.5	80	40	39	30	245	185	Nov. 63
Nebr:	Omaha	1.17	1.16	1.6	1.7	50	30	29	25	100	90	Jan. 64
Nev:	Las Vegas	1.16	1.15	1.6	1.6	20	15	12	10	90	85	Oct. 63
N. H:	Manchester	1.20	1.20	1.6	1.6	60	50	43	38	355	310	Jan. 64
N. J:	Trenton	1.16	1.09	1.6	1.6	30	20	26	22	160	130	Dec. 63
N. Mex:	Albuquerque	1.12	1.04	1.6	1.6	20	10	12	12	50	50	Nov. 63
N. Y:	Buffalo	1.16	1.17	1.7	1.7	40	25	26	25	170	170	Dec. 63
	New York	1.14	1.12	1.6	1.6	60	40	41	37	225	215	Oct. 63
	Syracuse	1.19	1.19	1.6	1.6	45	35	31	28	165	155	Nov. 63
N. C:	Charlotte	1.17	1.14	1.4	1.5	80	40	35	35	155	125	Nov. 63
N. Dak:	Minot	1.16	1.18	1.5	1.6	130	100	60	56	170	160	Jan. 64
Ohio:	Cincinnati	1.20	1.18	1.6	1.6	40	20	28	25	95	70	Dec. 63
	Cleveland	1.16	1.18	1.6	1.6	40	25	24	20	125	110	Nov. 63
Okla:	Oklahoma City	1.13	1.13	1.4	1.4	55	30	22	20	90	75	Oct. 63
Ore:	Portland	1.22	1.21	1.4	1.5	50	35	33	33	190	190	Dec. 63
Pa:	Philadelphia	1.15	1.18	1.6	1.6	55	20	26	22	140	115	Nov. 63
	Pittsburgh	1.20	1.18	1.6	1.6	60	30	36	34	190	170	Nov. 63
P. R:	San Juan	1.14	1.14	1.4	1.4	35	15	14	12	95	65	Nov. 63
R. I:	Providence	1.19	1.19	1.7	1.7	45	25	35	28	225	180	Jan. 64
S. C:	Charleston	1.17	1.17	1.4	1.4	60	35	26	25	150	140	Dec. 63
S. Dak:	Rapid City	1.07	1.23	1.5	1.7	100	60	49	47	175	150	Oct. 63
Tenn:	Chattanooga	1.20	1.16	1.4	1.4	110	50	46	38	185	120	Oct. 63
	Memphis	1.18	1.20	1.4	1.5	75	30	33	30	100	70	Jan. 64
Tex:	Austin	1.14	1.17	1.5	1.5	20	10	10	14	55	60	Oct. 63
	Dallas	1.16	1.14	1.5	1.5	40	20	19	17	75	60	Dec. 63
Utah:	Salt Lake City	1.13	1.08	1.5	1.7	55	30	30	25	205	160	Nov. 63
Vt:	Burlington	1.16	1.16	1.6	1.7	55	40	39	32	245	230	Dec. 63
Va:	Norfolk	1.15	1.14	1.4	1.5	45	20	23	23	115	95	Dec. 63
Wash:	Seattle	1.20	1.20	1.5	1.6	55	40	36	36	205	205	Oct. 63
	Spokane	1.22	1.20	1.5	1.6	55	30	30	26	160	140	Dec. 63
W. Va:	Charleston	1.13	1.14	1.4	1.5	85	45	34	30	120	85	Oct. 63
Wis:	Milwaukee	1.24	1.24	1.8	1.8	30	20	21	17	130	120	Jan. 64
Wyo:	Laramie	1.15	1.14	1.5	1.5	45	25	27	20	125	125	Jan. 64
Network average		1.17	1.16	1.5	1.6	52	31	28.4	25.6	147	128	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was < 10 pc/liter.

an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as the measured concentration at which the statistical two-standard-deviation analytical error is 100 percent (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; Cs^{137}, 5; Ba^{140}, 10; and I^{131}, 10.

Data Presentation

Table 1 presents summaries of the analyses for September 1963 (September 1-28, 1963). Although not shown in table 1, the iodine-131 and barium-140 monthly average concentrations in milk were <10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used in calculating the monthly average. A similar procedure is used for the network average.

Figures 1, 2, and 3 are isoconcentration maps showing the estimated strontium-89, strontium-90, and cesium-137 concentration in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. In order to show the distribution of the network's stations versus radionuclide concentrations in milk, table 2 has

TABLE 2.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, SEPTEMBER 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5-10	5	<1-9	3	<10	62	<5-45	1	<10	62
15-20	15	10-19	9			50-95	24		
25-30	17	20-29	29			100-145	17		
35-40	14	30-39	16			150-195	13		
45-50	7	40-49	4			200-245	3		
55-60	3	50-59	1			250-295	3		
65-70	0					300-345	1		
>70	1								

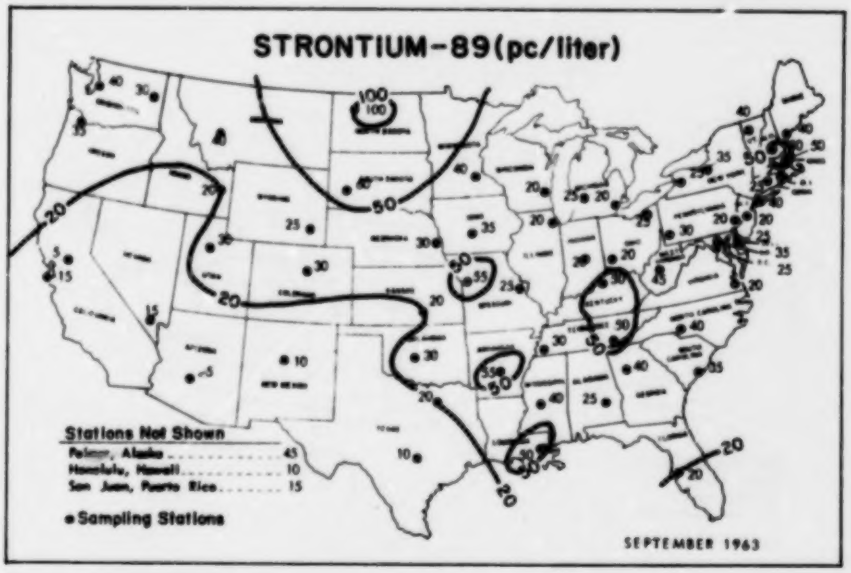


FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

been prepared using monthly average data shown in table 1.

Continuing the practice followed in previous issues of *Radiological Health Data*, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network at least twice a year.

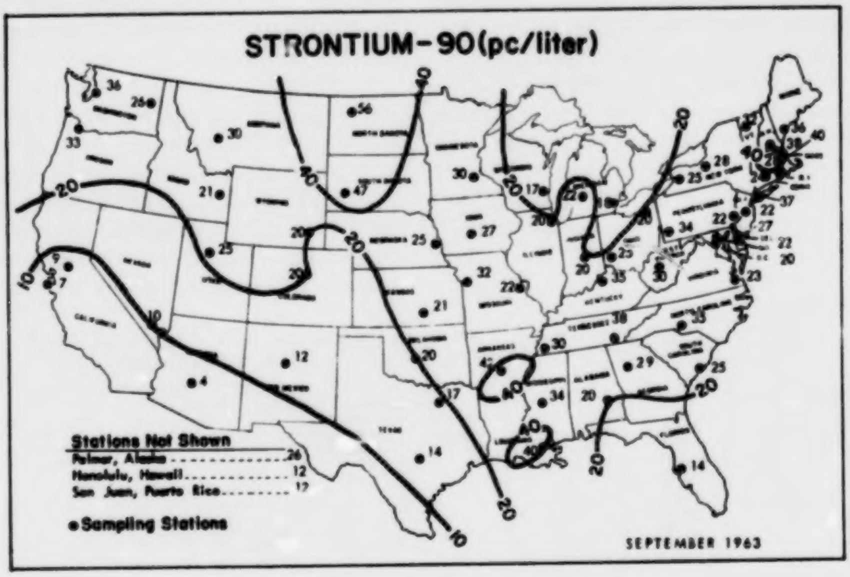

STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 26
Honolulu, Hawaii 12
San Juan, Puerto Rico 17
● Sampling Stations
SEPTEMBER 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

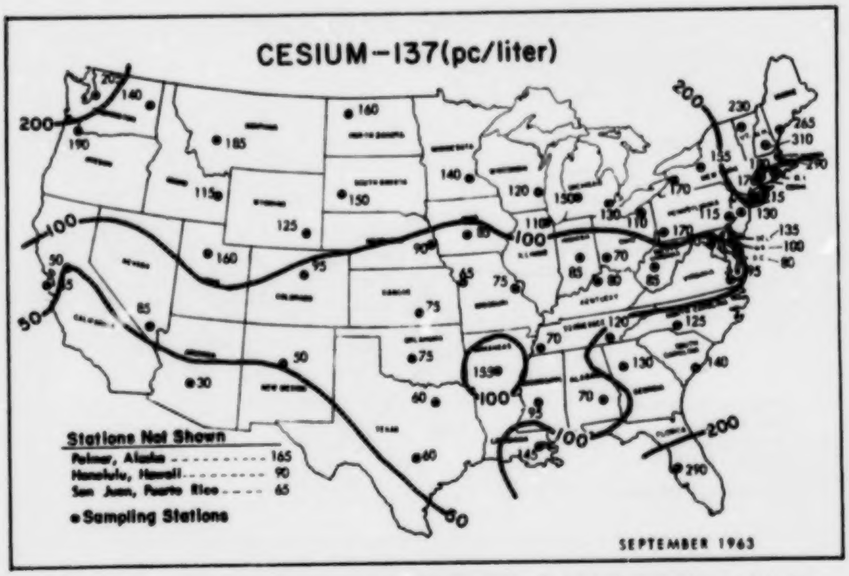

CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 165
Honolulu, Hawaii 90
San Juan, Puerto Rico 65
● Sampling Stations
SEPTEMBER 1963

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

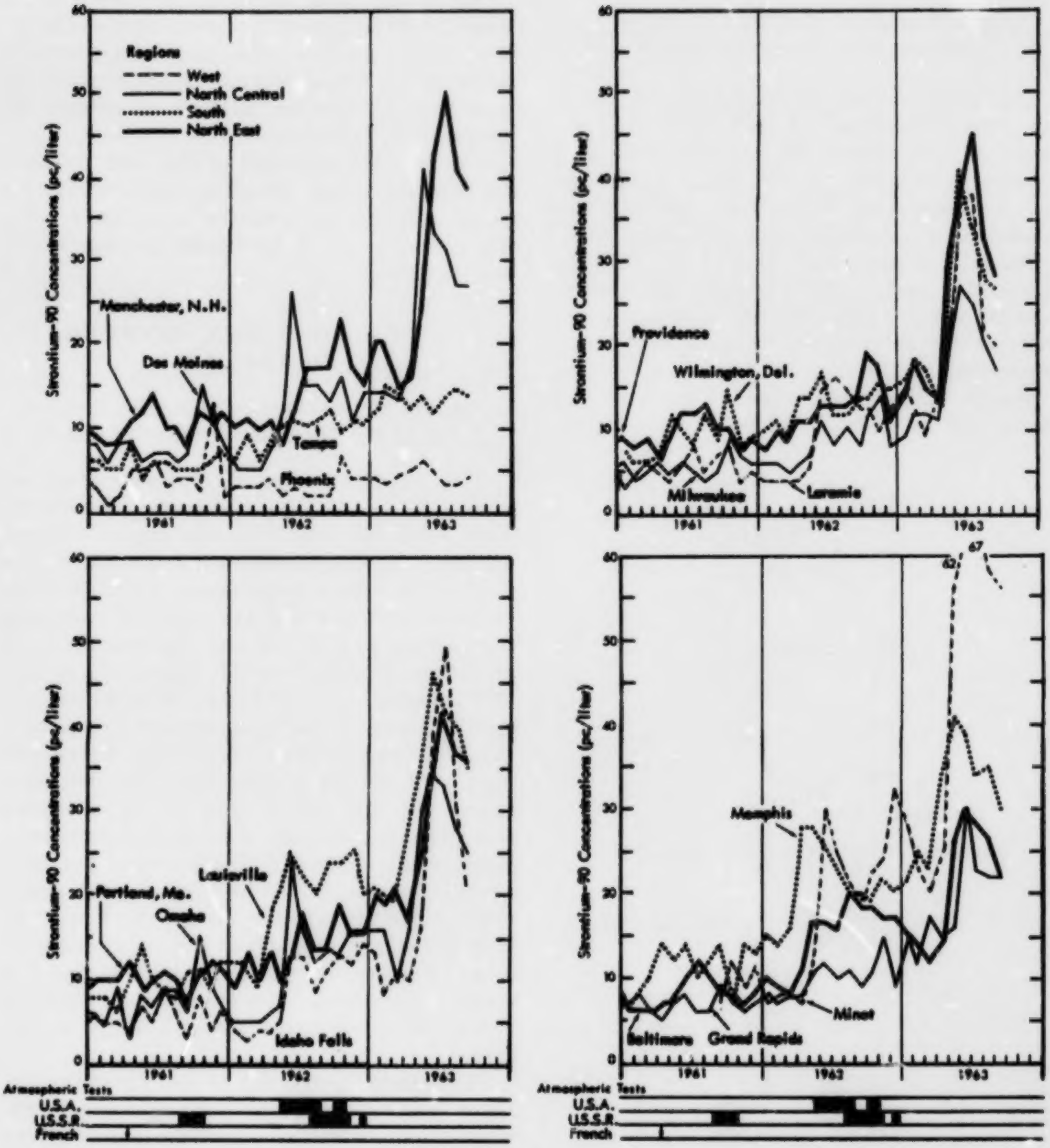


FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

2. INDIANA MILK NETWORK, SEPTEMBER 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-half-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

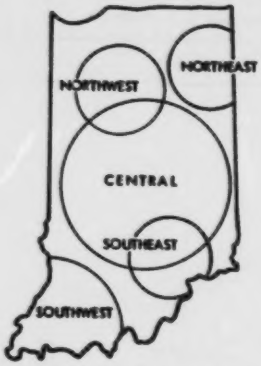


FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, SEPTEMBER 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	< 10	31	< 10	100	< 10
Southeast	< 10	34	< 10	60	< 10
Central	< 10	37	< 10	70	< 10
Southwest	< 10	34	< 10	55	< 10
Northwest	< 10	44	< 10	100	< 10
State average	< 10	36	< 10	75	< 10

An ion exchange analytical procedure (*2*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The State average is an arithmetic average of the station values.

3. NEW YORK MILK NETWORK, AUGUST 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 6)—are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium–89, strontium–90, iodine–131, cesium–137, and barium-lanthanum–140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine–131. In the event that any city reports iodine–131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

The matrix method (*3*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium–89 and strontium–90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with

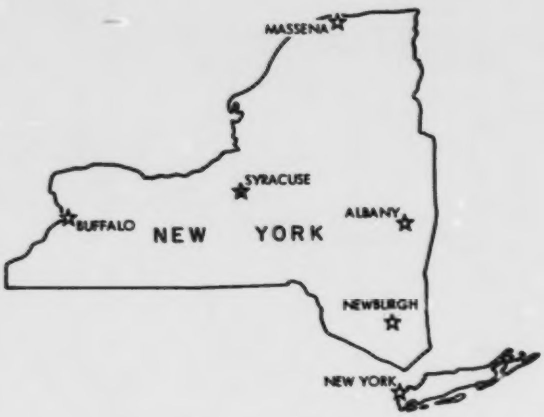


FIGURE 6.—NEW YORK MILK SAMPLING LOCATIONS

sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm^2 window. The strontium–90 portion is differentally estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium–90. The monthly average radionuclide concentrations in milk are shown in table 4.

TABLE 4.—RADIONUCLIDES IN NEW YORK MILK, AUGUST 1963

[Average concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$
Albany	49	29	< 20	132	< 20
Buffalo	33	20	< 20	93	< 20
Massena	50	31	< 20	226	< 20
Newburgh	53	37	< 20	134	< 20
New York City	81	33	< 20	133	< 20
Syracuse	36	29	< 20	110	< 20
Average	50	30	< 20	138	< 20

Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

4. RADIOSTRONTIUM IN MILK,[1] APRIL–JUNE 1963

Health and Safety Laboratory
U. S. Atomic Energy Commission

The Health and Safety Laboratory began monitoring liquid whole milk in New York City in 1954 for strontium–90 in order to estimate the dietary contribution from the ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, in 1954 and at Mandan, North Dakota in 1955. Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used for cattle feed, while the Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is from the island of Oahu where the cows are on pasture throughout the year, and it is of interest to know how well the strontium levels in milk in this area reflect changes in deposition rates.

The calcium and strontium–90 data are presented in tables 5 and 6. The fluctuations of strontium–90 with time are shown in figures 7 and 8.

TABLE 5.—RADIOSTRONTIUM AND CALCIUM IN LIQUID MILK, APRIL–JUNE 1963

Sampling station and period	Calcium (g/liter)	Strontium-90 (pc/liter)	Strontium-90 (pc/g Ca)
New York City			
1959 Average			11
1960 Average			8.0
1961 Average			6.7
1962 Average			12
1963 First Quarter			11
April	0.96	11.6	12.1
May	1.00	40.8	40.6
June	1.00	42.4	42.4
Honolulu, Hawaii			
1959 Average			5.0
1960 Average			3.2
1961 Average			2.4
1962 Average			4.3
1963 Average			6.0
April	1.14	9.1	8.0
May	1.06	10.2	9.6
June	1.07	10.1	9.5

Comment

A marked increase in the strontium–90 content of milk from the continental U.S. stations was observed beginning in May 1963, due to the heavy spring fallout deposition.

---

[1] Data taken from *HASL–140* (4).

The Honolulu milk samples still contain less strontium-90 per liter than those of other sampling stations, although there was a slight increase in strontium-90 concentrations in the Honolulu samples in May also.

TABLE 6.—RADIOSTRONTIUM AND CALCIUM IN POWDERED MILK AND BUTTERMILK, APRIL–JUNE 1963

Sampling station and period	Calcium (g/kg)	Strontium-90 (pc/kg)	Strontium-90 (pc/g Ca)
Powdered milk			
Perry, New York			
1959 Average			8.0
1960 Average			6.5
1961 Average			6.2
1962 Average			11.1
1963 First Quarter			11.9
April	7.8	92	11.8
May	8.7	158	18.3
June	5.6	171	30.5
Powdered Buttermilk			
Mandan, North Dakota			
1959 Average			25.7
1960 Average			15.0
1961 Average			9.4
1962 Average			25
1963 First Quarter			29.3
April	12.6	532	42.4
May	11.6	1214	105
June	16.8	950	56.5

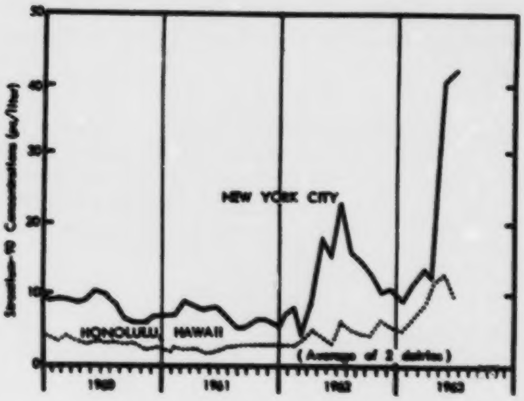


FIGURE 7.—STRONTIUM-90 IN LIQUID MILK SAMPLES

Recent coverage in *Radiological Health Data*:

Period	Issue
August–December 1961	*June 1962*
January–February 1962	*September 1962*
March–June 1962	*January 1963*
July–September 1962	*April 1963*
October 1962–March 1963	*October 1963*

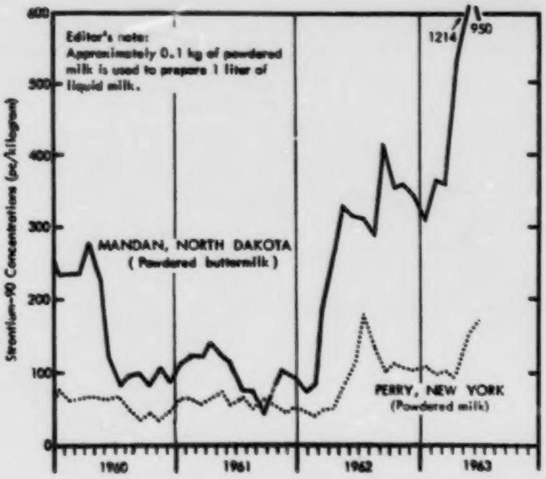


FIGURE 8.—STRONTIUM-90 IN POWDERED MILK SAMPLES

5. CANADIAN MILK NETWORK,[1] SEPTEMBER 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89 and cesium-137, as well as strontium-90.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa for analysis. The contri-

---

[1] Data from *Radiation Protection Programs, Vol. 1, No. 10*: 25–31, Radiation Protection Division, Canadian Department of National Health and Welfare. (October 1963).

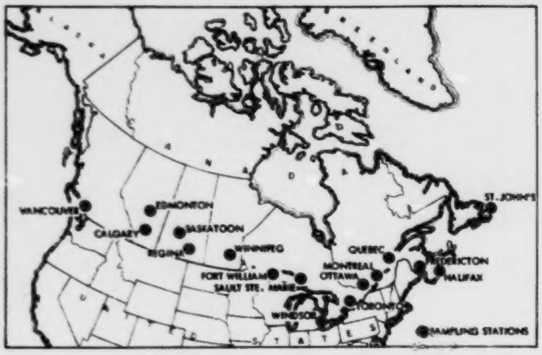


FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

bution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Iodine–131 is determined on a portion of each sample; the remaining portion is combined into monthly composites for the determination of strontium–90, strontium–89 and cesium–137.

Analytical Methods

For the analysis of iodine–131, radiochemical methods (*5*) are used. Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulphite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with polyethylene sheet. The residue is ashed in a muffle furnace at 450° C, dissolved in dilute nitric acid, and strontium is separated on an ion-exchange column (*6, 7*). The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrim–90 daughter isotope, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 × 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier". In the determination of cesium this factor is not involved.

The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in reference (*8*). For example, the 2σ total errors (representing 95 percent confidence) associated with a measured concentration of 10 pc/liter, in units of pc/liter are Sr^{89}, 2.5; Sr^{90}, 1.5; I^{131}, 5; and Cs^{137}, 6.

Results

Table 7 presents monthly averages of strontium–89, strontium–90, cesium–137, iodine–131, and stable calcium and potassium in Canadian whole milk. Figures 10 and 11 show the variation of the network average of the radionuclides content of Canadian whole milk.

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the

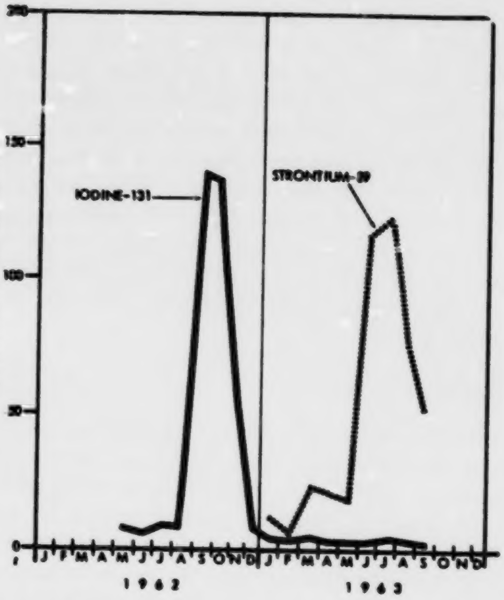


FIGURE 10.—IODINE-131 AND STRONTIUM-89 CONCENTRATIONS IN CANADIAN WHOLE MILK

Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*9*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

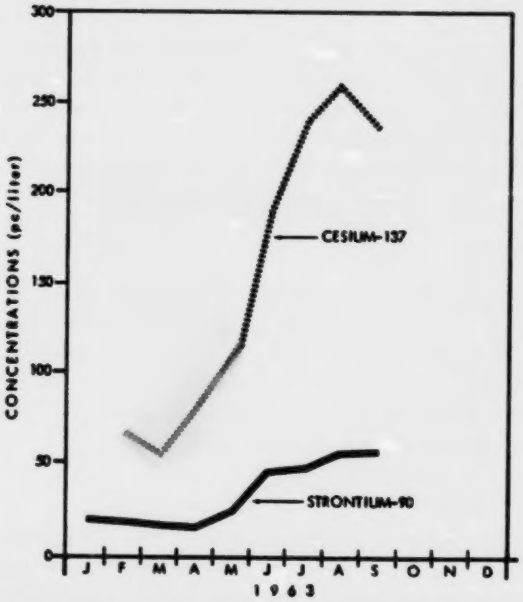


FIGURE 11.—STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, SEPTEMBER 1963

[Radionuclide Concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89	Strontium-90	Iodine-131	Cesium-137
Calgary	1.36	1.4	60	53.2	1	209
Edmonton	1.34	1.5	47	44.2	2	188
Ft. William	1.32	1.5	69	58.5	0	264
Fredericton	1.34	1.5	79	80.4	1	382
Halifax	1.30	1.4	59	74.2	0	282
Montreal	1.29	1.5	65	54.4	0	219
Ottawa	1.26	1.5	31	40.4	2	196
Quebec	1.30	1.6	44	49.2	1	338
Regina	1.34	1.5	70	78.2	1	149
St. John's, Nfld.	1.21	1.4	62	72.4	2	280
Saskatoon	1.32	1.5	32	27.2	0	171
Sault Ste. Marie	1.31	1.5	56	65.1	1	264
Toronto	1.31	1.4	30	22.1	5	153
Vancouver	1.42	1.5	43	49.3	3	341
Windsor	1.35	1.4	13	16.3	0	54
Winnipeg	1.15	1.5	53	51.7	5	216
Average	1.31	1.5	51	52.3	2	232

REFERENCES

(*1*) Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data, 4*: 291–6, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

(*2*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*: 1306–8 (September 1961).

(*3*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2,* (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education and Welfare, Washington, D.C. 20201

(*4*) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–140*, 154–6, Office of Technical Services, Department of Commerce, Washington, D.C. 20401 (October 1, 1963), price $4.00.

(*5*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine–131 in Milk, RPD–23*, Radiation Protection Division, Department of National Health and Welfare, (October 1963).

(*6*) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW–RP–1*, (July 1958).

(*7*) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD–5*, Radiation Protection Division, Department of National Health and Welfare, (June 1, 1960).

(*8*) Public Health Service: Canadian Milk Network, *Radiological Health Data 4*: 561–3, Superintendent of Documents, Government Printing Office, Washington D.C. 20401 (November 1963).

(*9*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Moving Annual Average Radionuclide Concentrations in Pasteurized Milk, October 1962—September 1963

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) may be used to assess that portion of an individual's or a population's radiation dose attributable to milk consumption by determining both the annual average concentrations of specific radionuclides of interest in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90 and iodine–131 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*2, 3*).

Employing an assumption that the average daily milk consumption of an individual in a population group is one liter, permits comparisons to be made between the daily rates of intake of the above radionuclides from the milk component of the diet and the Federal Radiation Council's action ranges of transient daily rates of intake (*4*). The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk, sampled by the PHS Pasteurized Milk Network, are presented in table 1. These averages are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in 12 consecutive months are averaged to obtain the annual average. To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter), in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Pasteurized Milk Network, *Radiological Health Data*, *4*: 551–557, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (November 1963).

(*2*) Bureau of the Census, Department of Commerce, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* *4*: 15–17, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U.S. Households, July 1962, *Radiological Health Data*, *4*: 124–7, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, *3*: ii–iii, Superintendent of Documents, Government Printing Office, Washington 25, D.C., (September 1962).

TABLE 1.—ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Iodine-131		Strontium-89		Strontium-90	
		September 1962–August 1963[a]	October 1962–September 1963[b]	September 1962–August 1963[a]	October 1962–September 1963[b]	September 1962–August 1963[a]	October 1962–September 1963[b]
Ala:	Montgomery	16	15	67	68	19	19
Alaska:	Palmer	100	32	58	46	15	16
Ariz:	Phoenix	< 10	< 10	18	18	4	4
Ark:	Little Rock	37	36	137	139	38	40
Calif:	Sacramento	< 10	< 10	42	42	8	9
	San Francisco	11	< 10	73	75	12	12
Colo:	Denver	11	< 10	29	27	14	15
Conn:	Hartford	20	14	30	29	18	19
Del:	Wilmington	30	24	41	39	22	23
D. C:	Washington	22	17	46	46	19	19
Fla:	Tampa	18	18	36	37	13	18
Ga:	Atlanta	22	22	92	94	25	26
Hawaii:	Honolulu	11	11	36	37	8	9
Idaho:	Idaho Falls	17	14	46	45	19	20
Ill:	Chicago	28	20	29	28	18	18
Ind:	Indianapolis	29	23	41	39	20	20
Iowa:	Des Moines	41	31	74	72	20	22
Kans:	Wichita	25	23	58	52	17	18
Ky:	Louisville	26	23	103	104	29	30
La:	New Orleans	26	26	148	149	36	37
Maine:	Portland	20	15	37	35	23	25
Md:	Baltimore	22	17	53	58	20	20
Mass:	Boston	21	15	41	41	27	29
Mich:	Detroit	32	21	29	26	18	19
	Grand Rapids	24	18	26	24	16	17
Minn:	Minneapolis	29	21	63	59	25	26
Miss:	Jackson	24	25	147	148	30	31
Mo:	Kansas City	38	34	86	86	22	23
	St. Louis	23	19	58	57	19	19
Mont:	Helena	32	25	55	54	22	23
Nebr:	Omaha	35	29	60	58	21	22
Nev:	Las Vegas	< 10	< 10	22	20	7	8
N. H:	Manchester	19	14	39	38	25	27
N. J:	Trenton	21	17	32	30	19	19
N. Mex:	Albuquerque	13	11	25	25	7	8
N. Y:	Buffalo	22	13	31	29	19	20
	New York	30	22	39	39	23	25
	Syracuse	24	16	34	32	20	21
N. C:	Charlotte	< 10	< 10	73	74	27	28
N. Dak:	Minot	33	18	85	87	37	40
Ohio:	Cincinnati	34	27	51	48	22	23
	Cleveland	29	21	34	33	18	19
Okla:	Oklahoma City	32	31	77	77	22	22
Ore:	Portland	22	20	102	104	23	25
Pa:	Philadelphia	27	22	37	36	21	22
	Pittsburgh	36	31	45	44	24	25
P. R:	San Juan	[b]15	[d]15	[c]87	[d]88	[c]14	[d]14
R. I:	Providence	22	18	36	34	22	24
S. C:	Charleston	18	18	72	74	24	24
S. Dak:	Rapid City	34	22	70	71	26	28
Tenn:	Chattanooga	20	19	118	120	31	33
	Memphis	26	25	105	106	28	29
Tex:	Austin	30	30	39	39	8	9
	Dallas	47	47	91	92	20	20
Utah:	Salt Lake City	18	15	36	36	17	18
Vt:	Burlington	22	17	39	36	22	23
Va:	Norfolk	17	15	54	53	21	21
Wash:	Seattle	21	19	76	77	21	23
	Spokane	18	13	53	54	20	21
W. Va:	Charleston	16	14	76	76	27	28
Wis:	Milwaukee	35	25	30	28	15	16
Wyo:	Laramie	11	< 10	52	46	18	19
Network summary		25	19	58	58	20.4	21.2

[a] Annual averages were computed on basis of 53 weekly averages.
[b] Annual averages were computed on basis of 52 weekly averages.
[c] Average is for 49 weeks. (No sample was received in November 1962).
[d] Average is for 48 weeks. (No sample was received in November 1962).

SECTION III.—WATER

Radioactivity in Raw Surface Waters—National Water Quality Network, July 1963

Division of Water Supply and Pollution Control,
Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this Network has expanded to 128 stations as of December 1, 1963 (figure 1), operated jointly with State, Federal, and local agencies, and industry. Samples are taken from surface waters of all the major U.S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of

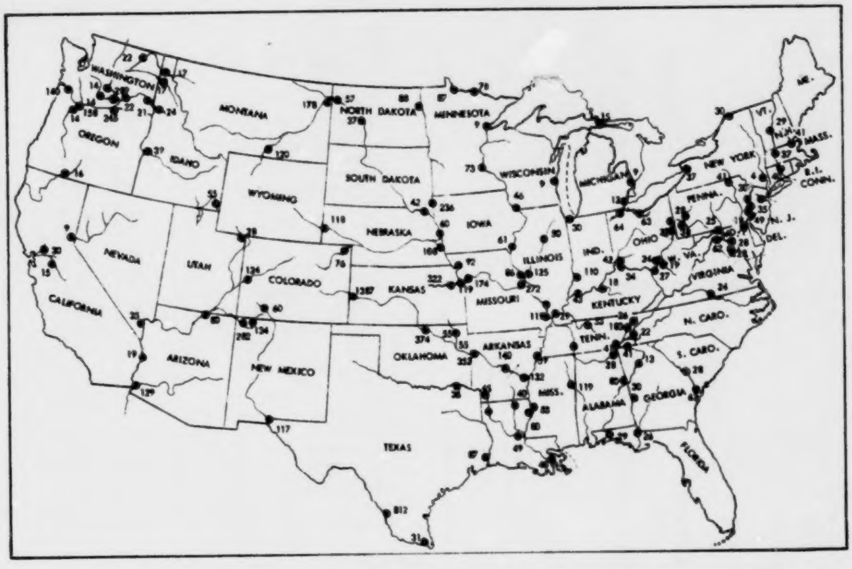

WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
WISCONSIN
ILLINOIS
MICHIGAN
IND.
OHIO
KENTUCKY
TENN.
MISS.
ALABAMA
GEORGIA
FLORIDA
S. CARO.
N. CARO.
VIRGINIA
W. VA.
PENNA.
NEW YORK
N. J.
DEL.
CONN.
R.I.
MASS.
VT.
N.H.
ME.
178
120
117
812
236
322
374
272
174
125
110
119
140
132

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, JULY 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, JULY 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	4	24	28	0	0	0
Animas River: Cedar Hill, N. Mexico	111	23	134	20	2	22
Apalachicola River:						
Chattahoochee, Fla	8	18	26	0	0	0
Arkansas River:						
Coolidge, Kansas	1284	103	1387	103	19	122
Ponca City, Okla	305	69	374	30	2	32
Fort Smith, Ark	266	86	352	25	2	27
Little Rock, Ark	78	62	140	2	1	3
Pendleton Ferry, Ark	73	59	132	4	0	4
Bear River: Preston, Idaho	5	50	55	0	1	1
Big Horn River:						
Hardin, Mont	84	36	120	16	9	25
Big Sioux River: Sioux Falls, S. Dak	139	97	236	2	6	8
Chattahoochee River:						
Atlanta, Ga	13	0	13	1	0	1
Columbus, Ga	12	18	30	0	0	0
Lanett, Ala	60	20	80	1	0	1
Chena Slough: Fairbanks, Alaska	6	10	16	0	0	0
Clearwater River:						
Lewiston, Idaho	13	11	24	0	0	0
Clinch River:						
Clinton, Tenn	13	13	26	< 1	0	< 1
Kingston, Tenn	19	164	183	< 1	2	2
Colorado River:						
Loma, Colo	57	67	124	8	14	22
Page, Ariz	8	72	80	0	7	7
Boulder City, Nev	0	35	35	0	12	12
Parker Dam, Calif-Ariz	0	19	19	0	9	9
Yuma, Ariz	0	129	129	0	2	2
Columbia River:						
Northport, Wash	5	17	22	0	0	0
Wenatchee, Wash	4	10	14	0	1	1
Pasco, Wash	31	258	289	0	0	0
McNary Dam, Oreg	42	203	245	0	< 1	< 1
Bonneville, Oreg	30	128	158	0	1	1
Clatskanie, Oreg	27	113	140	0	0	0
Cumberland River:						
Clarksville, Tenn	14	19	33	0	0	0
Connecticut River:						
Wilder, Vt	13	16	29	0	0	0
Northfield, Mass	22	15	37	1	0	1
Enfield Dam, Conn	17	23	40	0	0	0
Cuyahoga River:						
Cleveland, Ohio	12	51	63	< 1	1	1
Delaware River:						
Martins Creek, Pa	10	20	30	0	0	0
Philadelphia, Pa	11	24	35	0	0	0
Escambia River:						
Century, Florida	9	20	29	0	0	0
Great Lakes:						
Duluth, Minn	0	9	9	0	0	0
Sault Ste. Marie, Mich	2	13	15	0	0	0
Milwaukee, Wisc	0	9	9	0	1	1
Gary, Ind	2	28	30	1	3	4
Port Huron, Mich	0	9	9	0	0	0
Detroit, Mich	0	12	12	0	0	0
Buffalo, New York	18	19	37	0	0	0
Green River: Dutch John, Utah	3	25	28	0	2	2
Hudson River: Poughkeepsie, N. Y	2	2	4	0	0	0
Illinois River:						
Peoria, Ill	16	34	50	0	0	0
Grafton, Ill	54	32	86	10	0	10
Kanawha River: Winfield Dam, W. Va	0	19	19	0	0	0
Klamath River: Keno, Oreg	3	13	16	0	0	0
Kansas River: De Soto, Kans	261	61	322	22	2	24
Maumee River; Toledo, Ohio	7	57	64	< 1	1	1
Little Miami River:						
Cincinnati, Ohio	0	42	42	1	1	2
Merrimack River:						
Lowell, Mass	15	26	41	0	0	0
Mississippi River:						
St. Paul, Minn	10	63	73	1	3	4
Dubuque, Iowa	0	46	46	0	1	1
Burlington, Iowa	15	46	61	0	0	0
E. St. Louis, Ill	81	44	125	5	2	7
Cape Girardeau, Mo	83	36	119	19	4	23
W. Memphis, Ark	24	35	59	1	1	2
Vicksburg, Miss	50	33	83	5	1	6
Delta, La	70	10	80	9	0	9
New Orleans, La	8	32	40	0	1	1
Missouri River:						
Williston, N. Dak	10	47	57	0	2	2
Bismarck, N. Dak	3	34	37	0	3	3
Yankton, S. Dak	7	35	42	0	4	4
Omaha, Nebr	24	36	60	2	4	6
St. Joseph, Mo	58	34	92	9	5	14
Kansas City, Kans	84	35	119	14	5	19
Missouri City, Mo	154	20	174	14	2	16
St. Louis, Mo	219	53	272	21	2	23
Monongahela River:						
Pittsburgh, Pa	3	35	38	0	0	0
North Platte River:						
Henry, Nebr	55	63	118	2	11	13
Ohio River:						
Addison, Ohio	3	21	24	0	0	0
Huntington, W. Va	4	23	27	0	0	0
Cincinnati, Ohio	8	26	34	2	0	2
Louisville, Ky	1	17	18	0	0	0
Evansville, Ind	13	30	43	0	0	0
Cairo, Ill	4	25	29	1	0	1
Toronto, Ohio	2	31	33	0	< 1	< 1
Ouachita River:						
Bastrop, La	13	27	40	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	4	13	17	1	1	2
Platte River: Plattsmouth, Nebr	51	57	108	3	4	7
Potomac River:						
Williamsport, Md	1	24	25	0	1	1
Great Falls, Md	4	24	28	0	0	0
Washington, D. C	1	27	28	0	0	0
Rainy River:						
Baudette, Minn	23	64	87	0	0	0
International Fls., Minn	17	61	78	0	0	0
Red River, North:						
Grand Forks, N. Dak	11	77	88	1	2	3
Red River, South:						
Denison, Tex	4	32	36	0	3	3
Index, Ark	11	34	45	1	1	2
Bossier City, La	41	42	83	5	0	5
Alexandria, La	12	37	49	1	1	2
Rio Grande River:						
Alamosa, Colo	25	35	60	1	3	4
El Paso, Tex	76	41	117	10	6	16
Laredo, Tex	757	55	812	11	3	14
Brownsville, Tex	14	17	31	0	1	1
Roanoke River: John H. Kerr Resr. & Dam, Va	11	13	24	1	0	1
Sabine River: Ruliff, Tex	52	35	87	2	0	2
Sacramento River:						
Courtland, Calif	15	15	30	1	0	1
San Joaquin River:						
Vernalis, Calif	4	11	15	1	2	3
San Juan River: Shiprock, N. Mex	211	71	282	24	24	48
St. Lawrence River:						
Massena, N. Y	15	15	30	1	0	1
Schuylkill River:						
Philadelphia, Pa	10	39	49	0	0	0
Savannah River:						
North Augusta, Ga	16	12	28	1	0	1
Port Wentworth, Ga	24	39	63	0	0	0
Shenandoah River:						
Berryville, Va	43	19	62	1	0	1
Ship Creek: Anchorage, Alaska	2	8	10	0	0	0
Snake River:						
Ice Harbor Dam, Wash	4	17	21	0	1	1
Wawawai, Wash	6	16	22	0	1	1
Payette, Idaho	9	30	39	0	3	3
South Platte River:						
Julesburg, Colo	10	66	76	1	29	30
Spokane River: Post Falls, Idaho	7	10	17	0	0	0
Susquehanna River:						
Sayre, Pa	10	31	41	0	0	0
Conowingo, Md	2	16	18	0	0	0
Tennessee River:						
Lenoir City, Tenn	9	13	22	0	0	0
Chattanooga, Tenn	9	32	41	< 1	< 1	1
Bridgeport, Ala	2	26	28	0	0	0
Pickwick Landing, Tenn	18	23	41	1	0	1
Tombigbee River:						
Columbus, Miss	80	39	119	1	0	1
Truckee River: Farad, Calif	1	8	9	0	0	0
Verdigris River:						
Nowata, Okla	21	34	55	0	1	1
Wabash River: New Harmony, Ind	72	38	110	2	< 1	2
Willamette River:						
Portland, Oreg	4	10	14	0	0	0
Yakima River: Richland, Wash	0	14	14	0	2	2
Yellowstone River:						
Sidney, Mont	141	37	178	15	2	17
Maximum	1284	258	1387	103	29	122
Minimum	0	0	4	0	0	0

Note: These data are preliminary; reanalysis of some samples and analyses which are not complete at the time of this report will be included in the network's *Annual Compilation of Data* (6).

radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1-6*).

The participating agencies collect one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium–90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample showing unusually high activity during the first analysis. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. References sources of U_3O_8, which give a known count-rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium–90 analyses have been made on three-month composites of aliquots from weekly samples. Until the fourth quarter of 1961, the method used for determining strontium–90 was that described in the aforementioned reference (*7*). Tributyl phosphate was used to extract ingrown yttrium–90 from the purified, coprecipitated strontium–90. Since that time, a modification of a procedure described by Harley has been used (*8*). The yttrium–90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrim oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Table 1 presents July 1963 results of alpha and beta analyses of U.S. raw surface waters. These data are preliminary; reanalysis of some samples and some analyses which are not completed at the time of this report will be included in the Network's *Annual Compilation of Data* (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made. The quarterly strontium–90 results for the past year are presented in table 2.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the July 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver *et al* (*9*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data*, PHS Publication No. 663, 1958 Edition, Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

TABLE 2.—QUARTERLY STATION AVERAGE CONCENTRATIONS OF STRONTIUM-90 IN RAW SURFACE WATERS, JULY 1962–JUNE 1963

[Concentrations in pc/liter]

Station	Third Quarter 1962	Fourth Quarter 1962	First Quarter 1963	Second Quarter 1963
Allegheny River: Pittsburgh, Pa	2.1	1.8	[a]—	1.8
Animas River: Cedar Hill, N. Mex	0.4	0.9	—	—
Apalachicola River: Chattahoochee, Fla	0.4	0.4	—	—
Arkansas River				
Coolidge, Kansas	2.6	1.0	—	—
Ponca City, Okla	4.8	2.2	—	5.9
Pendleton Ferry, Ark				5.5
Bear River: Preston, Idaho	[b]1.3	0.9	—	—
Big Horn River: Hardin, Mont	3.7	1.3	—	5.8
Big Sioux River: Sioux Falls, S. Dak	5.4	2.5	—	—
Chattahoochee River				
Atlanta, Ga	0.7	1.0	3.6	1.6
Columbus, Ga	[c]0.8	1.1	—	1.5
Lanett, Ala	1.5	0.8	—	—
Chena Slough: Fairbanks, Alaska	0.4	0.3	—	0.7
Clearwater River: Lewiston, Idaho	0.5	0.4	—	—
Clinch River				
Clinton, Tenn	1.3	1.0	6.3	—
Kingston, Tenn	12.6	—	—	5.6
Colorado River				
Yuma, Ariz	1.2	0.9	—	0.9
Parker Dam, Ariz.-Calif	1.7	1.3	—	—
Boulder City, Nev	1.7	1.5	—	1.8
Page, Ariz	1.5	6.9	1.5	—
Loma, Colo	0.8	0.5	—	2.5
Columbia River				
Clatskanie, Oreg	0.6	0.9	—	1.3
Bonneville, Oreg	0.4	1.2	—	—
McNary Dam, Oreg	1.4	1.0	1.4	1.1
Pasco, Wash	1.8	1.5	2.3	2.4
Wenatchee, Wash	1.2	1.6	—	1.1
Northport, Wash	1.3	0.9	—	—
Connecticut River				
Northfield, Mass	1.3	1.0	—	1.4
Enfield Dam, Conn	1.4	1.0	—	—
Wilder, Vt	1.4	0.9	—	—
Cuyahoga River: Cleveland, Ohio		—	1.4	—
Delaware River				
Philadelphia, Pa	1.6	2.4	—	1.1
Martins Creek, Pa	0.5	1.2	—	1.7
Trenton, N. J	1.5	0.9	—	
Escambia River: Century, Florida	1.0	—	—	1.4
Great Lakes:				
Lake Superior:				
Duluth Minn	0.7	0.7	—	0.4
St. Marys River:				
Sault Ste. Marie, Mich	0.9	0.8	—	—
Lake Michigan:				
Milwaukee, Wis	0.9	0.8	—	0.8
St. Clair River:				
Port Huron, Mich	1.0	0.8	—	1.3
Lake Erie:				
Buffalo, N. Y	1.3	1.7	—	2.2
Detroit River:				
Detroit, Mich	1.5	1.1	—	—
Lake Michigan:				
Gary, Ind	1.0	0.7	—	—
Green River: Dutch John, Utah	1.9	1.2	—	—
Hudson River: Poughkeepsie, N. Y	1.7	3.0	—	3.8
Illinois River				
Pere Marquette State Park Grafton, Ill	1.4	1.8	—	—
Peoria, Ill		1.7	—	3.5
Kanawha River: Winfield Dam, W. Va	1.3	1.1	—	—
Klamath River: Keno, Oreg	2.8	0.9	—	1.4
Kansas River: De Soto, Kans	—	—	—	4.9
Little Miami River: Cincinnati, Ohio	0.9	1.6	—	—
Maumee River: Toledo, Ohio	—	—	3.6	4.9
Merrimack River: Lowell, Mass	—	0.9	—	—
Mississippi River				
New Orleans, La	2.1	1.9	—	—
Vicksburg, Miss	2.0	2.0	—	—
Delta, La	1.1	2.1	—	3.3
W. Memphis, Ark	2.4	2.0	—	3.6
Cape Girardeau, Mo	3.1	2.7	—	—
East St. Louis, Ill	2.7	1.8	—	4.0
Burlington, Iowa	2.1	2.1	—	—
Dubuque, Iowa	—	—		2.6
Lock & Dam #3, St. Paul, Minn	4.9	3.4	—	—
Missouri River				
St. Louis, Mo	2.5	2.7	—	—
Missouri City	2.2	2.6	—	4.1
Kansas City, Kans	3.4	3.4	—	—
St. Joseph, Mo	5.7	1.9	—	6.2
Omaha, Nebr	3.8	2.5	—	—
Yankton, S. Dak	2.3	2.3	—	3.3
Bismarck, N. Dak	1.4	1.7	—	—
Williston, N. Dak	3.0	1.5	—	2.5
Monongahela River: Pittsburgh, Pa	1.8	1.5	—	2.7
North Platte River: Henry, Nebr	2.1	0.6	—	2.5
Ohio River				
Cairo, Ill	1.4	1.7	—	2.9
Evansville, Ind	1.3	1.6	—	—
Louisville, Ky	3.3	1.4	—	2.3
Cincinnati, Ohio	1.5	1.6	—	—
Huntington, W. Va	1.5	1.6	—	1.9
Addison, Ohio	1.3	2.1	—	—
E. Liverpool	—	—	—	
Toronto, Ohio				—
Ouachita River: Bastrop, La	1.0	1.6	—	—
Pend Oreille River: Albeni Falls Dam, Idaho	0.5	0.7	—	0.9
Platte River: Plattsmouth, Nebr	4.1	2.3	—	—
Potomac River				
Great Falls, Md	1.2	1.0	—	—
Williamsport, Md	1.2	1.6	—	1.4
Washington, D. C				—
Rainy River				
International Falls, Minn	1.4	1.8	—	2.9
Baudette, Minn	1.7	2.2	—	2.5
Red River (South)				
Alexandria, La	2.0	3.9	—	4.0
Bossier City, La	2.2	2.0	—	—
Index, Ark	—	3.3	—	5.3
Denison, Tex	1.1	5.0	—	—
Rio Grande River				
Alamosa, Colo	0.5	0.5	—	1.1
El Paso, Tex	1.7	0.7	—	—
Laredo, Tex	1.8	1.8	—	3.7
Brownsville, Tex	0.7	1.3	—	—
Roanoke River: John H. Kerr Resr. & Dam, Va	1.8	1.1	—	1.3
Sabine River: Ruliff, Tex	1.0	1.4	—	—
Sacramento River				
Greens Landing, Calif	0.8	0.9	—	
Courtland, Calif				—
San Joaquin River: Vernalis, Calif	0.7	1.0	—	1.3
San Juan River: Shiprock, N. Mex	1.0	1.7	—	1.9
Savannah River				
Port Wentworth, Ga	2.2	0.6	2.4	2.2
North Augusta, Ga	0.8	0.6	—	—
Schuylkill River: Philadelphia, Pa	1.8	1.3	—	—
Shenandoah River: Berryville, Va	0.4	0.8	—	1.2
Ship Creek: Anchorage, Alaska	—	0.3	—	—
Snake River				
Ice Harbor Dam, Wash	1.1	1.6	—	—
Wawawai, Wash	0.9	0.7	—	0.9
Payette, Idaho	1.1	0.8	—	1.5
South Platte River: Julesburg, Colo	2.2	0.8	—	1.7
Spokane River: Post Falls, Idaho	0.9	0.8	—	—
Susquehanna River				
Conowingo, Md	2.1	1.2	—	1.6
Sayre, Pa	1.0	1.0	—	—
Tennessee River				
Pickwick Landing Dam, Tenn	1.1	1.4	—	—
Bridgeport, Ala	0.6	1.0	—	1.6
Chattanooga, Tenn	1.2	1.4	2.6	1.7
Lenoir City, Tenn	2.8	1.0	—	1.5
Tombigbee River: Columbus, Miss	1.6	0.6	—	—
Truckee River: California-Nevada Border Farad, Calif	0.7	0.9	—	1.0
Verdigris River: Nowata, Okla	2.3	2.5	—	4.2
Wabash River: New Harmony, Ind	2.0	1.4	—	3.1
Willamette River: Portland, Wash	0.5	0.6	—	0.7
Yakima River: Richland, Wash	0.3	0.7	—	—
Yellowstone River: Sidney, Mont	1.5	2.0	—	—
Maximum	12.6	6.9	6.3	6.2
Minimum	0.3	0.3	0.4	0.4

[a] Dash indicates no data received.
[b] Aug.-Sept. composite.
[c] Six months composite.

36

(3) *Ibid.*, 1960 Edition.[1]

(4) *Ibid.*, 1961 Edition.[1]

(5) *Ibid.*, 1962 Edition (in press).

(6) *Ibid.*, 1963 Edition (to be published).

(7) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition New York (1960).

(8) Harley, J. H.: Radiochemical Determination of Strontium–90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U.S. Atomic Energy Commission, New York Operations Office (1962).

(9) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962. *Radiological Health Data*, 4: 306–16, Superintendent of Documents, Government Printing Office, Washington 25, D.C. (June 1963).

---

[1] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education, and Welfare, Washington 25, D.C.

Radiostrontium in Tap Water, January–April 1963[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium–90 concentrations in tap water at New York City since August 1954 and at Richmond, California since April 1958. Samples of tap water are collected daily at each site so that by the end of the month a composite of at least 100 liters is available for analysis. Also, determinations of strontium–89 have been made since September 1961 (*1*).

Data for the past several years are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report (*2*). Strontium–90 concentrations and strontium–89/strontium–90 ratios for January through April 1963 appear in table 1.

Monthly average strontium–90 concentra-

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month	New York City[a]		Richmond, California[b]	
	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}
1959 Average	0.40		0.29	
1960 Average	0.47		0.26	
1961 Average	0.32		0.25	
1962 Average	0.72		0.23	
1963				
January	0.94	6.2	0.24	7.4
February	0.52	5.4	0.28	8.5
March	1.03	4.3	0.36	7.8
April	1.07	4.7	lost	lost

[a] From 100–200 liters per sample.
[b] Approximately 100 liters per sample.
Note: Strontium–89 extrapolated to midpoint of sampling period.

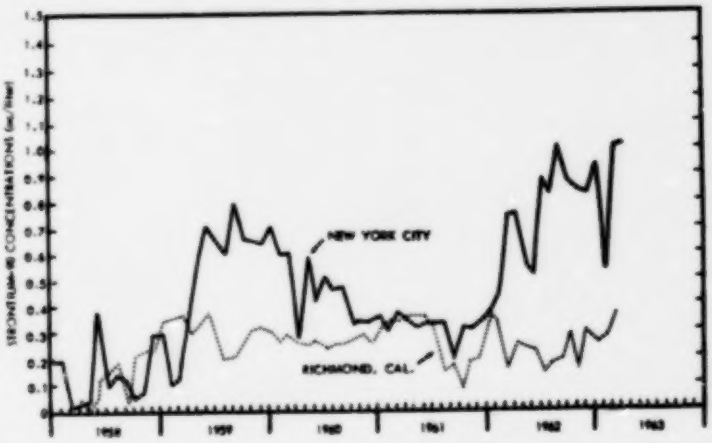


FIGURE 1.—STRONTIUM–90 CONCENTRATIONS IN TAP WATER

tions in tap water at New York City which averaged 0.72 pc/liter during 1962 had increased to 1.07 pc/liter by April 1963. Levels at Richmond, California, which normally are lower than those observed in New York City, ranged between 0.24 and 0.36 pc/liter during the first four months of 1963.

---

[1] Data taken from *HASL–140* (*1*).

The strontium-89/strontium-90 ratios indicate that the fallout was probably not of any more recent origin when strontium-90 concentrations were high than when they were low.

The maximum strontium-90 concentrations observed are well below the acceptable limit of 10 pc/liter as set forth in the interstate carrier drinking water standards (*3*).

REFERENCES

(*1*) U.S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-140*: 154, Office of Technical Services, Department of Commerce, Washington, D.C., 20230, (October 1, 1963), price $4.00.

(*2*) U.S. Atomic Energy Commission: *Environmental Contamination from Weapons Tests, HASL-42*, Office of Technical Services, Department of Commerce, Washington, D.C. 20230, (October 1962), price $3.50.

(*3*) Federal Register Rules and Regulations: *Title 42—Public Health* Chapter 1—Public Health Service, Department of Health, Education, *and Welfare*; *Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards, 27*: 2154–5, Superintendent of Documents, Government Printing Office, Washington, D.C., 20401 (March 6, 1962).

Recent coverage in *Radiological Health Data*:

Period	Issue
Second quarter 1961	*March 1962*
Third and fourth quarters 1961	*June 1962*
January–April 1962	*September 1962*
March–June 1962	*January 1963*
July–December 1962	*July 1963*

SECTION IV.—OTHER DATA

Preliminary Survey of Dairy Cattle Feeding Practices

Carl D. Olsen[1]

Information on dairy cattle feeding practices is necessary in the development of mathematical models for predicting radionuclide concentrations in milk. Additionally, the feeding practices are of importance for investigating the mechanisms by which radionuclides move from the environment into milk. Some reports suggest that modification of these feeding practices may permit some control of the radionuclide content of milk (*1–4*). The above reasons prompted a preliminary survey of dairy cattle feeding practices which was conducted during the first half of 1963 by the Division of Environmental Engineering and Food Protection, PHS.

The data obtained through the survey of feeding and pasture practices are presented in figure 1. This figure shows the average periods during which dairy cattle are on pasture in various areas of the country. These periods are approximate and will vary from year to year, depending on individual farming practice, rainfall, elevation, and seasonal temperature deviations.

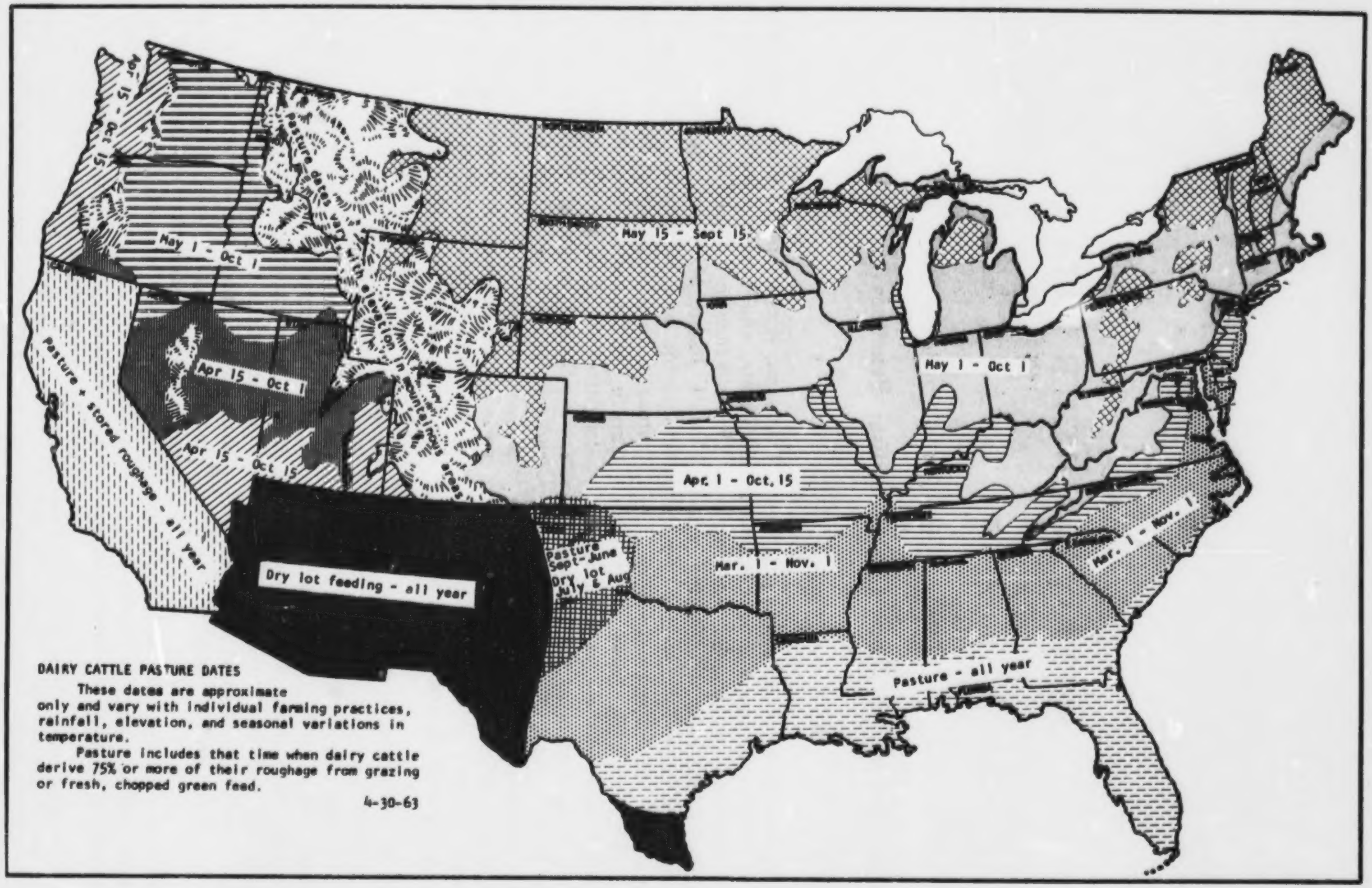
The data were obtained from dairy extension agents, dairy nutritionists, and health department personnel in Alabama, Arkansas, Georgia, Louisiana, Mississippi, Nebraska, New Mexico, Oklahoma, and Texas. Public Health Service personnel furnished similar data for California, Florida, Idaho, Maryland, Michigan, Oregon, Washington and Wisconsin. The data were plotted on maps furnished by the U.S. Weather Bureau, and the pasture dates were interpolated along the lines of the average dates of the first frost in the fall, or the last average frost date in the spring. For the purposes of this report, pasture periods are considered to be those periods when the cattle are receiving 75 percent or more of their roughage from grazing or from fresh, chopped, green feed.

It was found that those areas along the Gulf Coast, the East Coast north to the southern border of North Carolina, the West Coast, and the San Joaquin and Sacramento valleys of California pasture their cattle all year around, except for certain areas of high land value where the cattle are fed in a "dry lot." These latter areas include the southern tip of Texas and the environs of Los Angeles. Arid areas such as New Mexico, Arizona and the El Paso, Texas, and Las Vegas, Nevada, areas are also predominantly dry lot feeding areas. Here the forage is grown on irrigated land, and is cut and carried to the cattle in a dry lot.

In general, there was little, if any, summer carry-over of stored feed in the Southern States. The mild climate of the South permits most

---

[1] Dr. Olsen is Staff Veterinarian, Milk and Food Branch, Division of Environmental Engineering and Food Protection, Public Health Service, Department of Health, Education and Welfare, Washington, D.C. 20201.


Apr 15 - Oct 15
May 1 - Oct 1
Pasture dates vary with elevation in mountainous areas
May 15 - Sept 15
May 1 - Oct 1
Apr 15 - Oct 1
Pasture + stored roughage - all year
Apr 15 - Oct 15
Apr. 1 - Oct. 15
Pasture Sept-June Dry lot July & Aug
Dry lot feeding - all year
Mar. 1 - Nov. 1
Mar. 1 - Nov. 1
Pasture - all year

DAIRY CATTLE PASTURE DATES

These dates are approximate only and vary with individual farming practices, rainfall, elevation, and seasonal variations in temperature.

Pasture includes that time when dairy cattle derive 75% or more of their roughage from grazing or fresh, chopped green feed.

4-30-63

FIGURE 1.—APPROXIMATE DATES DAIRY CATTLE ARE ON PASTURE

dairymen to get by on a minimum of stored feed. In the northern half of the country, normal dairy practice is to store enough hay for the winter months, plus a little extra. Generally, dairymen carry over about a 30-day supply of stored feed to the following year. The rainfall, length of winter, and length of summer pasture seasons will cause the amount of carryover to vary somewhat from year to year.

Winter housing varies with the region. In the Northern States' snow belt, the cattle are generally confined to the barn during those months when there is snow cover on the pastures. In those States south of the snow belt, the housing is usually of the shed type with one side open and the cattle are permitted to roam or graze old pastures or cornfields. In most areas of the South and Southwest, housing for cattle is minimal.

This limited investigation into dairy cattle feeding practices on a national basis was based on the collection and collation of the average periods during which dairy cattle receive 75 percent or more of their roughage from grazing or from fresh, chopped, green feed. For a more precise description of dairy cattle feeding practices these data must be supplemented by data from individual farms and for specific years.

REFERENCES

(*1*) National Advisory Committee on Radiation: *Radioactive Contamination of the Environment: Public Health Action*, Division of Radiological Health, Public Health Service, U.S. Department of Health, Education and Welfare, Washington, D.C. 20201. (May 1962).

(*2*) Minnesota Department of Health and University of Minnesota: *Factors Influencing Strontium-90 in Milk From the Brainerd, Minn. Milkshed*, PHS Publication No. 999-R-1, Public Inquiries Branch, Public Health Service, U.S. Department of Health, Education and Welfare, Washington, D.C. 20201 (December 1962).

(*3*) Hansen, W. G., J. E. Campbell, J. H. Fooks, H. C. Mitchell, and C. B. Eller: *Influence of Farming Practices on Concentrations of Fission Products in Milk*, Public Health Service Publication 999-R-6, to be published.

(*4*) Kahn, B., C. P. Straub and I. R. Jones: *Radioiodine in Milk of Cows Consuming Stored Feed and of Cows on Pasture*: *Science 138*: 1334-5, (December 1962).

41

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 21 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. A summary follows for Hanford Atomic Products Operation.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee of Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in National Bureau of Standards "Handbook 69." The MPC values applicable to the following reports are given in table 1.

HANFORD ATOMIC PRODUCTS OPERATION,[1] CALENDAR YEAR 1962

General Electric Co.
Richland, Washington

The Hanford Atomic Products Operation, located in a semi-arid region of southeastern Washington, is a 500-square mile complex of nuclear reactors, fuel fabrication plants, chemical separation facilities and research and development laboratories. Various radioactive wastes which result from plant operations are disposed of through controlled releases to the atmosphere, ground, and the water of the Columbia River. A primary responsibility of plant personnel is to monitor effluents in order to safeguard against any effects these wastes have on the 80,000 residents of Richland, Pasco, Kennewick, and other communities in the vicinity of the project.

---

[1] Summarized from Hanford Atomic Products Operation, *Evaluation of Radiological Conditions in the Vicinity of Hanford for 1962*, HW–76526, February 25, 1963.

TABLE 1.—SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS IN THIS SUBSECTION

Line No.	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water (pc/liter)	Air (pc/m³)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present[a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present[a]	600	—
3	If Ra^{226}, Ra^{228} are not present[a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present[a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, Pu^{241} are not present[a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{231}, Pu^{241}, Bk^{249} are not present[a]	—	100
8	Arsenic-76	20,000	3,000
9	Copper-64	200,000	40,000
10	Chromium-51	2,000,000	80,000
11	Iodine-131[b]	2,000	300
12	Manganese-56	100,000	20,000
13	Neptunium-239	100,000	30,000
14	Phosphorus-32	20,000	2,000
15	Silicon-31	5,000	0.06
16	Sodium-24	200,000	30,000
17	Strontium-90[b]	100	10
18	Zinc-65	100,000	2,000

[a] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulations, a group of nuclides may be considered not present if the ratio of each nuclide is equal to or less than 1/10 of its appropriate MPC and if the sum of these ratios for the group in question is equal to or less than ¼.

[b] The Federal Radiation Council guidance is expressed in terms of daily intake. The top of Range II is 100 pc/day for Iodine-131 and 200 pc/day for strontium-90.

The monitoring program includes surveillance of the atmosphere, vegetation, fish and wildlife, milk and agricultural produce, and the waters of the Columbia River and Pacific Ocean. Further measurements are made of external radiation and possible ground contamination from burial pits.

Atmosphere

Gaseous wastes are released to the atmosphere through 200-foot stacks after removal of most radioactive material orginally present.

The Hanford project maintains air sampling stations at Benton City, Kennewick, Pasco, Richland, Seattle, Spokane, Walla Walla, and Yakima, Washington; Meacham, and Klamath Falls, Oregon; Boise and Lewiston, Idaho; and Great Falls, Montana. Sample filters are changed weekly and sent to Hanford for analyses. Quarterly averages of beta concentration during 1962 are presented in table 2.

Releases of iodine–131 are of particular interest and routine measurements are made at several locations around the plant area. Stack releases averaged 0.35 curies per day in 1962. The concentrations in the local environmental air are shown in table 3.

TABLE 2.—AVERAGE AIRBORNE BETA ACTIVITY AT SELECTED PACIFIC N.W. LOCATIONS, 1962

[Average concentrations in pc/m³]

Sampling locations	First quarter	Second quarter	Third quarter	Fourth quarter
Richland, Washington	6.4	4.5	4.4	7.3
Spokane, Washington	4.1	3.6	3.4	3.8
Boise, Idaho	5.7	5.4	4.5	9.4
Meacham, Oregon	5.3	4.4	4.9	7.8
Seattle, Washington	3.6	2.6	2.3	6.2

Water

Hanford's eight production reactors are cooled by treated water pumped from the Columbia River. After the water passes through the reactors, it is returned to the river. Some radioactivity results from neutron activation of impurities remaining in the treated water and is discharged in the effluent. The major part (90 percent) of this radioactive material consists of Mn^{56}, Cu^{64}, Na^{24}, Cr^{51}, Np^{239}, As^{76}, and Si^{31}. Although the presence of Zn^{65}, P^{32}, and certain other radionuclides is of interest, they are found in lower quantities. River water samples are taken at Hanford Ferry, Pasco, and Vancouver to be analyzed for several radionuclides. Selected results are presented in table 4.

TABLE 3.—IODINE–131 IN AIR AT PERIMETER COMMUNITIES

[Average concentrations in pc/m³]

Sampling locations	1960	1961	1962	1962			
				1st quarter	2nd quarter	3rd quarter	4th quarter
Richland	0.030	0.023	0.038	0.028	0.024	0.056	0.030
North Richland	0.043	0.045	0.099	0.085	0.088	0.100	0.091
Benton City	0.054	0.022	0.081	0.018	0.073	0.126	0.108
Pasco	0.023	0.036	0.077	0.068	0.024	0.109	0.113

TABLE 4.—CONCENTRATIONS OF SELECTED RADIONUCLIDES IN THE COLUMBIA RIVER WATER, 1962

[Concentrations in pc/liter]

Sampling location	Calendar year 1962	Na^{24}	P^{32}	Zn^{65}	As^{76}	I^{131}	Np^{239}
Hanford Ferry	Maximum	11,000	600	1,800	4,800	34	3,900
(raw water)	Minimum	610	86	150	620	5.4	690
(24 samples)	Average	6,100	260	420	1,500	12	2,100
Pasco	Maximum	2,400	590	510	660	11	1,900
(raw water)	Minimum	170	50	110	180	<1.4	340
(27 samples)	Average	1,600	180	220	470	<6	980
Pasco	Maximum	1,400	210	270	420	17	1,300
(treated domestic water)	Minimum	89	<2.6	<11	<50	<1.1	[a]
(50 samples)	Average	600	44	95	<200	<6	550
Vancouver	Maximum		110	140			180
(raw water)	Minimum		8.4	<15			[a]
(19 samples)	Average	[b]	38	64	[b]	[b]	77

[a] Not detected.
[b] Not analyzed.

Fish and Wildlife

Fish in the Columbia River accumulate some of the radionuclides present in water, and whitefish in particular concentrate phosphorus–32, which is a major bone seeker. The average concentration of phosphorus–32 in the flesh of whitefish caught near the plant was 350 pc/g, somewhat lower than the 530 pc/g average for 1961.

Migratory waterfowl which may have utilized the Hanford section of the Columbia River were obtained from hunters in Washington, Oregon, Idaho, and California. Analyses of 102 of these specimens showed that one out of 17 contained concentrations of phosphorus–32 greater than the detection level of 50 pc/g. The maximum concentration found was 1,800 pc P^{32}/g.

Milk and Agricultural Produce

There is no farming within about a 13–mile radius of the chemical separations facilities (the major local source of air-borne radionuclides), but the Ringold farms and Riverview District of Pasco, which are respectively about 15 and 30 miles downstream from the reactors, take water from the Columbia River. Some radionuclides, especially Zn^{65} and P^{32}, are traced through the irrigation process into milk and produce.

Dairy farms in the Ringold and Riverview areas were found to have average Zn^{65} concentrations in milk of 960 pc/liter and 590 pc/liter, respectively, and the average P^{32} concentrations were 760 pc/liter and 850 pc/liter, respectively. Neither Zn^{65} nor P^{32} was positively detected in milk distributed through commercial outlets.

Hanford analyses of milk known to be of local origin showed Sr^{90} concentrations ranging from less than 2 to 24 pc Sr^{90}/liter, with an average concentration of 5.1 pc Sr^{90}/liter. Concentrations of Sr^{89} and Cs^{137} in milk analyzed at Hanford were usually below the detection levels of 4 pc Sr^{89}/liter and 30 pc Cs^{137}/liter.

With the exception of the P^{32} and Zn^{65} in milk obtained from local farms irrigated with Columbia River water, the radionuclide content of milk available commercially in the area appears typical of that reported by Public Health Service for sections of the country with similar rainfall.

In addition to the above nuclides, measurements for I^{131} were made in all milk samples. During the early part of the year, concentrations of I^{131} in local milk were well below 10 pc/liter. Nuclear tests by the U.S. during the spring and early summer caused temporary increases in concentrations of I^{131} in local milk to a maximum of 70 pc/liter. A sharp rise in I^{131} concentrations occurred during the latter part of August and in September in both local and commercial milk coincident with the resumption of nuclear testing by the U.S.S.R. On October 31, a maximum concentration of 580 pc I^{131}/liter was measured in milk from the Ringold area. Relatively high concentrations persisted until the latter part of December, at which time the I^{131} content dropped to less than 10 pc/liter of milk. Radioactive decay of I^{131} and the decreased use of fresh pasture accounts for the sharp reduction of I^{131} measured in milk at the end of the year.

Miscellaneous local produce was purchased periodically from the markets and farms during the growing season and radioassayed. The average concentration of I^{131} measured in leafy vegetables sampled from local farms and vegetable markets during the period of May through September was 200 pc/kg.

External Radiation

Ionization chambers located above ground and in the Columbia River were used to estimate the combined exposure from external sources in the Hanford area. Aboveground measurements indicated an annual exposure in 1961 of about 170 mr. Virtually all of this radiation is attributable to natural background.

The presence of gamma emitters, especially Na^{24}, in reactor effluent causes a higher exposure rate in the Columbia River. The average dose in the water near Richland was about 2.1 mr/day and near Pasco about 1.4 mr/day. This would mean that a person swimming or boating in the river for 240 hours per year would receive about 20 mr of exposure near Richland.

Previous coverage in *Radiological Health Data*

Period	Issue
1959 and first and second quarters 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*
Third and fourth quarter 1961	*October 1962*

Reported Nuclear Detonations, December 1963

Two low-yield underground nuclear detonations at the Nevada Test Site during December 1963 were reported by the Atomic Energy Commission. The first of these, conducted on December 4, 1963, was given the arbitrary reference number 146 by *Radiological Health Data*; the other test, conducted on December 12, was assigned reference number 147. (Low yield range has been defined as less than 20 kilotons.)

45

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 2
FEBRUARY 1964

TABLE OF CONTENTS

Page

SECTION I.— AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 45
1. Radiation Surveillance Network (October 1963), PHS 45
2. Canadian Air Monitoring Program (October 1963) 49
3. Mexican Air Monitoring Program (October 1963) 50
4. Pan American Air Sampling Program (October 1963), PAHO and PHS 51
5. Gross Beta Activity in Air, North America (October 1963) 51
Fission Product Gamma Activity in Airborne Particulates 53
The 80th Meridian Network (September 1963), AEC 53
Monthly Deposition of Various Radionuclides 55
Fallout in the United States and Other Areas (January-March 1963), AEC 55

SECTION II.—MILK AND FOOD

Milk Surveillance 57
1. Pasteurized Milk Network (October 1963) 57
2. Indiana Milk Network (October 1963) 62
3. New York Milk Network (September 1963) 62
4. Oregon Milk Network (July-October 1963) 63
5. Canadian Milk Network (October 1963) 65
Moving Annual Average Radionuclide Concentrations in Pasteurized Milk (November 1962-October 1963) 68
Effect of the Evaporation and Powdering Processes on the Iodine-131 Content of Milk, A. E. Raymond and G. W. Williams 70
Strontium-90 and Calcium in United States Wheat (1962) and Milling Products (1958-1962), J. Rivera 72
Strontium-90 in Canadian Wheat, 1962, H. Taniguchi 75

SECTION III.—WATER

Radioactivity in Raw Surface Waters—National Water Quality Network (August 1963), PHS 77

SECTION IV.—OTHER DATA

Cesium-137 and Potassium in Finnish Lapps and Their Diet, J. K. Miettinen, A. Jokelainen, P. Roine, K. Lidén, and Y. Naversten 83
Strontium Turnover Rates in Human Bones, J. Rivera 98
Environmental Levels of Radioactivity at Atomic Energy Commission Installations 99
1. Brookhaven National Laboratory (July 1962-June 1963) 100
2. Rocky Flats Plant (July 1962-June 1963) 101
Reported Nuclear Detonations (January 1964) 103

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more intensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. October 1963 data from three networks were combined and are presented graphically by means of isogram lines on a map of North America (figure 5).

1. Radiation Surveillance Network, October 1963

Division of Radiological Health,
Public Health Service

The Radiation Surveillance Network (RSN) is made up of 73 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State Health Department personnel.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24 hour sampling period by a high volume centrifugal blower. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network's station operators report their field estimates daily to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C.

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 38,300 pc Sr^{90}–Y^{90} standard. Each filter is counted at least 3 days after the end of the sampling period and is recounted 7 days later. The intial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = $ (*1*).[1] The daily concentrations and estimated ages are reported by the PHS in a monthly RSN report (*2*).

The October 1963 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN data are presented with Canadian and Mexican air data in the form of isogram lines in figure 5.

---

[1] In this expression, A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T=1.

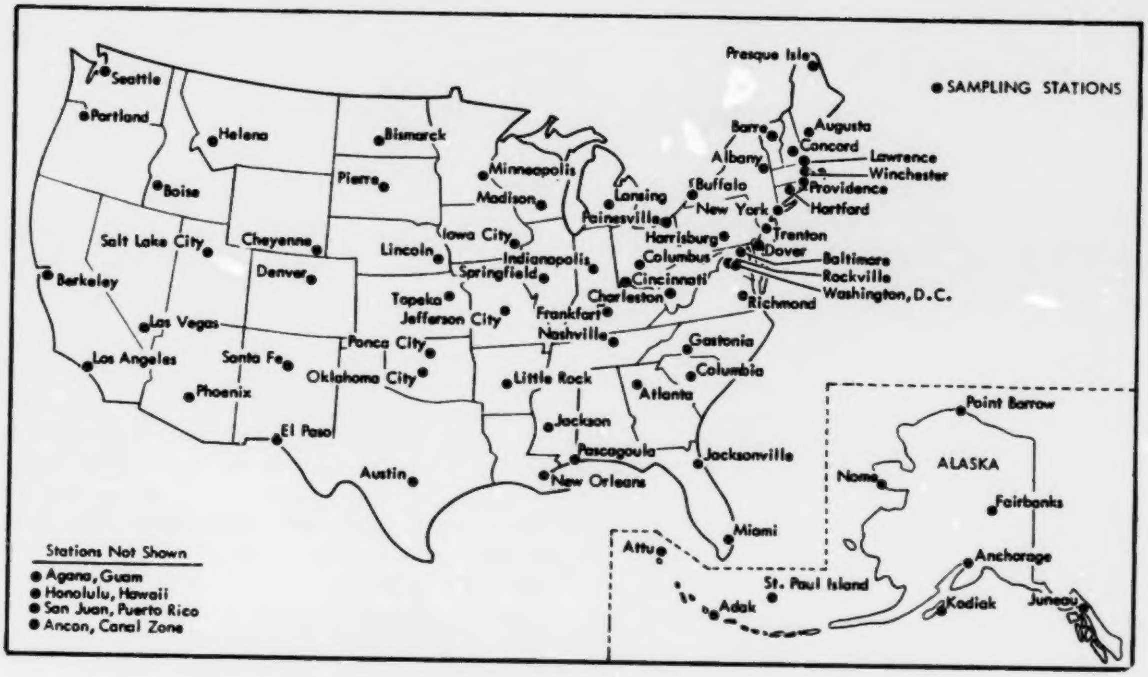

SAMPLING STATIONS
Seattle
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Santa Fe
Cheyenne
Denver
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
El Paso
Austin
Minneapolis
Madison
Iowa City
Indianapolis
Springfield
Little Rock
Jackson
Pascagoula
New Orleans
Lansing
Painesville
Columbus
Cincinnati
Charleston
Frankfort
Nashville
Atlanta
Gastonia
Columbia
Jacksonville
Miami
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
New York
Hartford
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, OCTOBER 1963

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta concentration of precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, C, is determined by:

$$C = \frac{\Sigma D}{\Sigma P} \times 1000$$

The October 1963 average concentrations and total depositions are given in table 2.

Profiles

The profiles of the monthly average fission product beta activity of airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *Radiological Health Data*. In recent issues, several profiles have been updated each month. The last column of table 1 gives the issue of Radiological Health Data having the most recent profile for each station. Seven profiles are updated in figure 2.

TABLE 1. FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR—RSN, OCTOBER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in RHD
Alaska:	Adak	31	2.7	< 0.10	0.87	Nov. 1963
	Anchorage	31	1.6	< 0.10	0.47	Jul. 1963
	Attu	29	2.6	0.21	1.1	Dec. 1963
	Fairbanks	28	1.1	< 0.10	0.41	Aug. 1963
	Juneau	29	1.8	< 0.10	0.61	Sep. 1963
	Kodiak	25	1.7	< 0.10	0.39	Oct. 1963
	Nome	12	0.8	< 0.10	0.43	Feb. 1964
	Point Barrow	30	1.9	< 0.10	0.64	Jan. 1964
	St. Paul Island	27	2.0	< 0.10	0.59	Apr. 1963
Ariz:	Phoenix	29	4.2	1.04	2.3	Sep. 1963
Ark:	Little Rock	30	3.7	0.93	2.3	Sep. 1963
Calif:	Berkeley	31	2.0	0.48	1.2	Oct. 1963
	Los Angeles	25	3.2	1.1	2.1	Feb. 1964
Canal Zone	Ancon	19	0.2	< 0.10	< 0.13	[b]
Colo:	Denver	29	4.2	0.42	2.2	Nov. 1963
Conn:	Hartford	31	3.2	0.54	1.6	Oct. 1963
Del:	Dover	22	2.4	0.81	1.4	Aug. 1963
D.C:	Washington	30	3.3	0.49	1.9	Mar. 1963
Fla:	Jacksonville	30	3.2	0.74	1.9	Oct. 1963
	Miami	25	4.2	0.68	1.8	Feb. 1964
Ga:	Atlanta	5	2.8	1.3	2.0	Jul. 1963
Guam:	Agana	26	1.4	< 0.10	0.45	Mar. 1963
Hawaii:	Honolulu	31	2.2	0.27	1.0	Nov. 1963
Idaho:	Boise	29	3.3	0.95	2.1	Dec. 1963
Ill.	Springfield	30	2.9	0.41	1.5	Oct. 1962
Ind:	Indianapolis	31	3.4	0.62	1.9	Jul. 1963
Iowa:	Iowa City	30	2.6	0.50	1.5	Jan. 1964
Kans:	Topeka	28	2.9	0.97	1.9	Jul. 1963
Ky:	Frankfort	31	3.3	0.56	1.7	Feb. 1964
La:	New Orleans	30	3.0	0.55	1.8	Nov. 1963
Maine:	Augusta	30	3.2	0.18	1.7	Mar. 1963
	Presque Isle	31	2.4	< 0.10	1.2	Nov. 1963
Md:	Baltimore	23	2.7	0.72	1.6	Nov. 1963
	Rockville	21	3.3	1.1	1.9	[b]
Mass:	Lawrence	30	3.8	0.48	2.1	Aug. 1963
	Winchester	30	3.3	0.49	1.8	[b]
Mich:	Lansing	30	3.1	0.58	1.8	Feb. 1964
Minn:	Minneapolis	28	3.2	0.35	1.4	Mar. 1963
Miss:	Jackson	26	4.0	0.76	2.4	Mar. 1963
	Pascagoula	14	3.3	0.98	2.3	Dec. 1963
Mo:	Jefferson City	31	3.3	0.64	1.7	Nov. 1963
Mont:	Helena	29	3.8	0.50	1.7	Nov. 1963
Nebr:	Lincoln	20	3.0	0.42	1.8	Apr. 1963
Nev:	Las Vegas	28	3.8	1.2	2.4	Jul. 1963
N.H:	Concord	21	3.4	0.53	2.2	Feb. 1964
N.J:	Trenton	31	2.9	0.62	1.6	Oct. 1962
N. Mex:	Santa Fe	24	4.5	0.59	1.9	Dec. 1963
N. Y:	Albany	26	3.7	0.65	2.0	Jul. 1963
	Buffalo	19	2.9	0.78	1.9	Nov. 1963
	New York	19	2.5	0.72	1.4	Dec. 1963
N. C:	Gastonia	30	3.8	0.86	1.9	Jan. 1964
N. Dak:	Bismarck	30	3.8	0.64	2.1	Feb. 1964
Ohio:	Cincinnati	22	2.6	0.50	1.6	Aug. 1963
	Columbus	27	2.9	0.63	1.7	Feb. 1963
	Painesville	31	3.4	0.76	2.1	Oct. 1963
Okla:	Oklahoma City	29	2.8	0.80	1.7	Apr. 1963
	Ponca City	31	2.3	0.36	1.1	Oct. 1963
Ore:	Portland	31	3.4	0.85	1.9	Oct. 1963
Pa:	Harrisburg	27	5.4	0.55	1.5	Jan. 1964
P.R:	San Juan	29	0.7	< 0.10	0.25	Apr. 1963
R. I:	Providence	31	3.8	0.61	1.9	Jan. 1964
S. C:	Columbia	27	2.3	0.50	1.3	Dec. 1963
S. Dak:	Pierre	29	3.7	0.40	1.9	Sep. 1963
Tenn:	Nashville	22	3.5	0.78	1.7	Jan. 1964
Tex:	Austin	31	3.7	0.71	1.9	Aug. 1963
	El Paso	30	3.5	0.75	1.8	Jan. 1964
Utah:	Salt Lake City	30	3.3	0.85	1.9	Aug. 1963
Vt:	Barre	31	3.6	0.49	2.1	Sep. 1963
Va:	Richmond	31	2.2	0.37	1.4	Sep. 1963
Wash:	Seattle	31	1.8	0.16	0.90	Jul. 1963
W. Va:	Charleston	29	2.6	0.49	1.5	Dec. 1963
Wisc.	Madison	29	3.4	0.49	1.9	Sep. 1963
Wyo:	Cheyenne	31	3.7	0.58	1.9	Aug. 1963
Network summary		1996	5.4	< 0.10	1.6	

[a] Weighted average obtained by summing the products of individual sampling times and the corresponding activities, and dividing by the summation of the individual sampling times. Values of < 0.10 are assumed to be 0.10 for averaging purposes. If the < 0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2. FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION—RSN, OCTOBER 1963

Station location		Average concentration [a] (pc/liter)	Total deposition measured [a] (nc/m²)
Alaska:			
	Anchorage	< 520	< 5.0
	Fairbanks	< 960	< 26
	Juneau	< 420	< 131
Ark:	Little Rock	[b]	[b]
Calif:	Berkeley	< 550	< 16
	Los Angeles	690	12
Colo:	Denver	1,800	5.0
Conn:	Hartford	1,000	10
D.C:	Washington	[b]	[b]
Fla:	Jacksonville	< 460	< 7.0
	Miami	< 410	< 46
Ga:	Atlanta	[b]	[b]
Idaho:	Boise	[b]	[b]
Ill:	Springfield	[b]	[b]
Ind:	Indianapolis	[b]	[b]
Iowa:	Iowa City	[b]	[b]
Kans:	Topeka	< 740	< 24
Ky:	Frankfort	1,600	8.0
La:	New Orleans	[b]	[b]
Maine:	Augusta	620	44
	Presque Isle	< 920	< 39
Md:	Baltimore	[b]	[b]
Mass:	Lawrence	760	32
	Winchester	1,200	32
Mich:	Lansing	1,900	12
Minn:	Minneapolis	670	13
Miss:	Jackson	[b]	[b]
Mo:	Jefferson City	< 430	< 9.0
Mont:	Helena	< 850	< 18
Nebr:	Lincoln	< 400	< 5.0
Nev:	Las Vegas	[b]	[b]
N.J:	Trenton	[b]	[b]
N. Mex:	Santa Fe	< 610	< 9.0
N.Y:	Albany	750	2.0
	Buffalo	[b]	[b]
N.C:	Gastonia	[b]	[b]
N. Dak:	Bismarck	660	23
Ohio:			
	Columbus	[b]	[b]
	Painesville	620	9.0
Okla:	Oklahoma City	< 400	< 6.0
	Ponca City	< 420	< 26
Ore:	Portland	< 440	< 26
Pa:	Harrisburg	[b]	[b]
P.R:	San Juan	< 590	< 68
R.I:	Providence	560	22
S.C:	Columbia	710	6.0
S. Dak:	Pierre	< 590	< 25
Tenn:	Nashville	[b]	[b]
Tex:	Austin	< 430	< 11
	El Paso	< 450	< 8.0
Utah:	Salt Lake City	< 520	< 15
Vt:	Barre	2,100	16
Va:	Richmond	830	6.0
Wash:	Seattle	< 490	< 38
W. Va:	Charleston	510	800
Wisc:	Madison	1,900	3.0
Wyo:	Cheyenne	< 400	< 10

[a] The minimum concentration reported for a single sample is 400 pc/liter. If the individual sample has a concentration of < 400 pc/liter, the deposition for that sample is calculated by $D = 0.4P$ in nc/m² (see text). A less-than sign is used with the monthly total deposition is the sum of the individual less-than values represents more than 10% of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] No evaporated sample received.

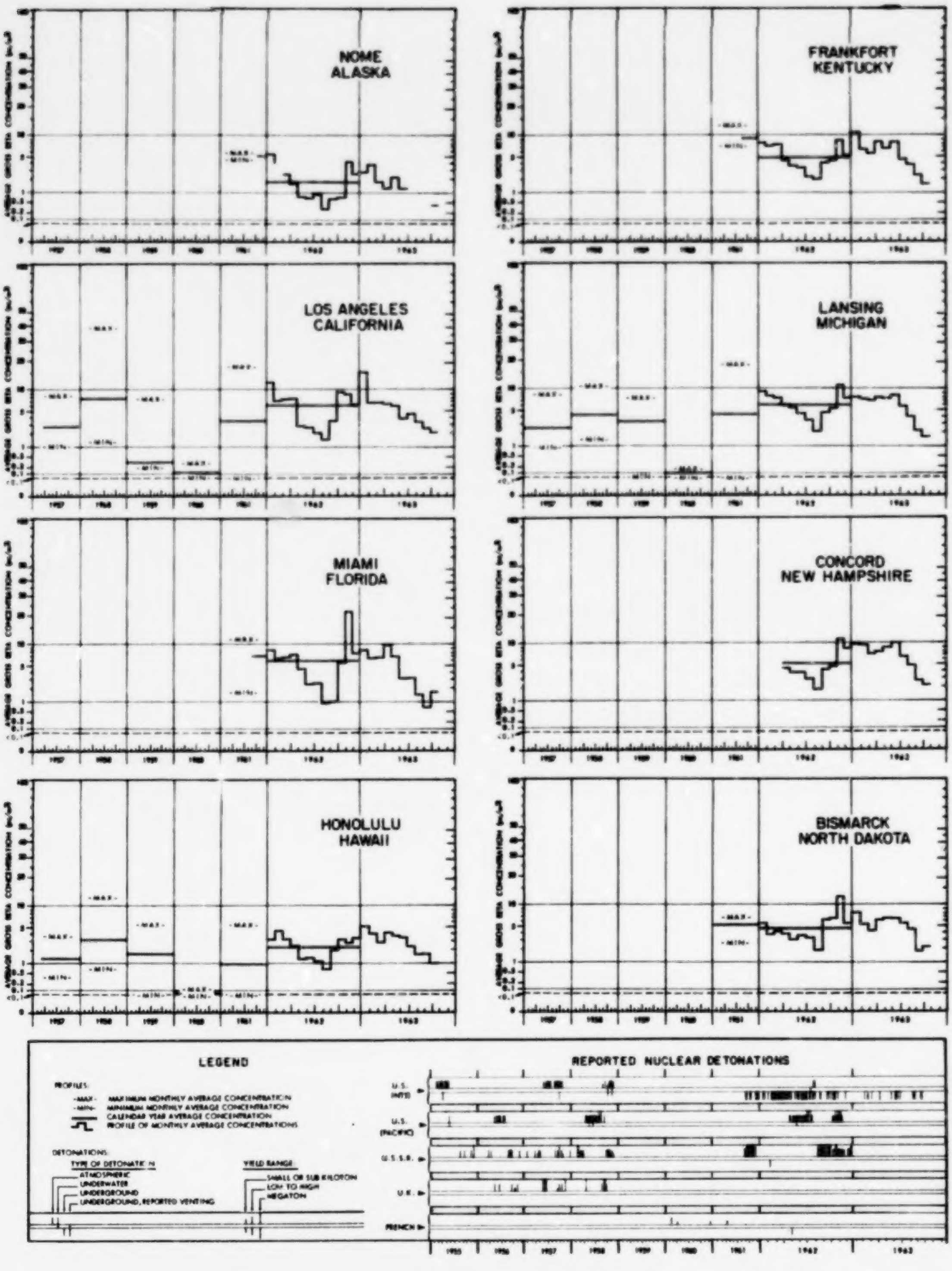


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957—OCTOBER 1963

50

2. Canadian Air Monitoring Program,[2] October 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a $Sr^{90}-Y^{90}$ standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for October 1963 are given in table 3 and presented in conjunction with U. S. and Mexican air data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory. Beta activities in precipitation for stations in Canada are presented in table 4.

---

[2] Data from *Radiation Protection Programs*, Vol. 1, No. 11:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare, (November 1963).

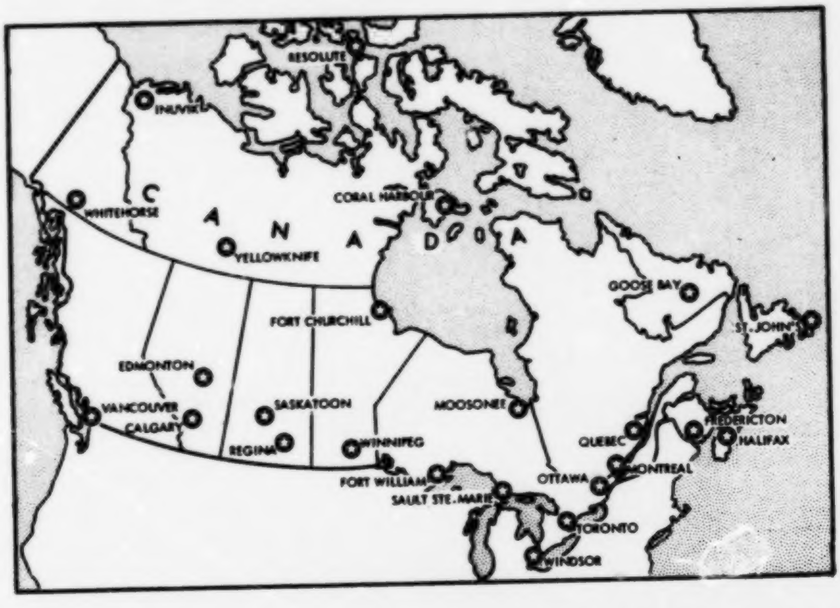

RESOLUTE
INUVIK
C
A
N
A
D
A
WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, OCTOBER 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, CANADA, OCTOBER 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	27	4.1	0.1	1.8
Coral Harbour	26	2.2	0.1	0.9
Edmonton	31	3.6	0.4	1.5
Ft. Churchill	31	2.1	0.1	1.0
Ft. William	31	3.7	0.2	1.6
Fredericton	15	3.1	0.8	1.8
Goose Bay	29	3.5	0.0	1.3
Halifax	26	3.9	0.0	1.8
Inuvik	31	2.4	0.1	0.8
Montreal	31	3.5	0.2	1.8
Moosonee	30	3.9	0.2	1.5
Ottawa	28	5.3	0.5	2.0
Quebec	31	3.1	0.3	1.5
Regina	31	5.4	0.6	2.2
Resolute	31	3.2	0.1	0.8
St. John's, Newfoundland	27	3.4	0.5	1.7
Saskatoon	30	5.0	0.1	2.0
Sault Ste. Marie	31	3.7	0.4	1.7
Toronto	31	3.4	0.4	0.8
Vancouver	30	3.3	0.7	1.4
Whitehorse	31	3.5	0.2	1.0
Windsor	28	3.4	0.4	1.9
Winnipeg	31	3.9	0.4	1.8
Yellowknife	31	2.9	0.3	1.1
Network summary	699	5.4	0.0	1.5

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, OCTOBER 1963

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	a	8.4
Coral Harbour	688	18.8
Edmonton	2079	26.4
Ft. Churchill	397	11.7
Ft. William	3629	24.9
Fredericton	349	41.5
Goose Bay	555	34.5
Halifax	598	47.3
Inuvik	461	22.5
Montreal	2161	30.2
Moosonee	1132	31.9
Ottawa	1455	25.9
Quebec	1305	75.2
Regina	1598	21.1
Resolute	112	19.8
St. John's, Newfoundland	453	38.7
Saskatoon	3642	20.3
Sault Ste. Marie	b	b
Toronto	810	12.5
Vancouver	865	132.7
Whitehorse	911	7.6
Windsor	2155	28.4
Winnipeg	2079	41.7
Yellowknife	2025	22.1
Average	1339	32.4

[a] Trace of precipitation.
[b] No sample.

3. Mexican Air Monitoring Program, October 1963

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network is made up of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Merida, Veracruz, San Luis Potosi and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Merida, the Instituto de Zonas Deserticas of the University of San Luis Potosi, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or more days a week, at the rate of approximately 1,800 cubic meters per day, through a high-efficiency glass fiber filter, 6 x 8 inch, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during October 1963 are presented in table 5. The data are also represented in the beta activity isogram map of North America, figure 5.

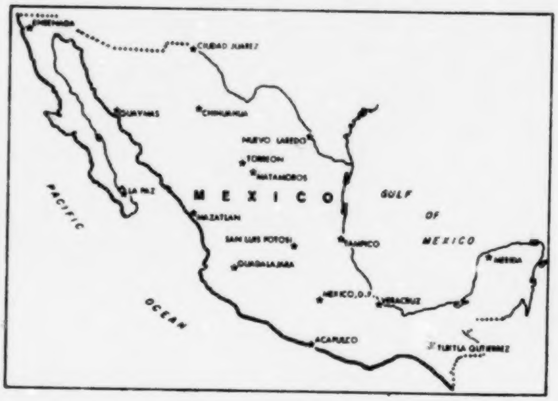


FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 5.—FISSION PRODUCT GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, OCTOBER 1963

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco [a]	0	—	—	—
Ciudad Juárez	18	3.1	0.1	1.8
Chihuahua	22	3.5	0.4	1.9
Ensenada	9	3.4	1.2	2.2
Guadalajara	7	1.9	0.3	1.0
Guaymas [a]	0	—	—	—
La Paz	14	3.7	0.7	2.2
Matamoros	6	3.2	0.6	1.5
Mazatlán [a]	0	—	—	—
Mérida	3	1.6	1.2	1.4
México, D.F. [b]	29	4.9	0.2	0.9
Nuevo Laredo	4	2.8	1.0	1.7
San Luis Potosí	12	3.6	0.3	1.1
Tampico	8	2.5	0.8	1.5
Torreón	13	6.0	0.2	2.2
Tuxtla Gutierrez a	0	—	—	—
Veracruz	12	4.5	1.3	2.5

[a] Sampling temporarily suspended.
[b] Mexico City.

4. Pan American Air Sampling Program, October 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas to develop their own radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile, is operated by the Occupational Health Service; in Lima, Peru, by the Institute of Occupational Health; and in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The October 1963 air monitoring results from the three participating countries are given in table 6. The Caracas station is shown on the gross beta concentration isogram map (figure 5). The October average at this station, adjusted by the RSN intercalibration factor[3] is <0.14 pc/m³, which is considrably below the lowest isogram line used on the map (1 pc/m³).

TABLE 6.—GROSS BETA ACTIVITY IN AIR, S. A., OCTOBER 1963

[Concentrations in pc/m³]

Sampling stations	Number of samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	22	0.18	< 0.10	< 0.11
Lima, Peru	0	—	—	—
Santiago, Chile	19	0.24	< 0.10	< 0.15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of < 0.10 are assumed to be 0.10 for averaging purposes. If the < 0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

5. Gross Beta Activity in Air, North America October 1963

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[4] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are therefore not the same as were previously used.

Figure 5 shows the October 1963 gross beta activity in air throughout North America based on data from the Canadian Air Monitoring Program, the Radiation Surveillance Network, and the Mexican Air Monitoring Program. The intercalibration factors used were derived in the Lockhart and Patterson report summary which appeared in *RHD*, January 1964 (*9*). The Canadian factor was arbitrarily set at 1.00 and the resulting factors for RSN and Mexican data were 1.28 and 0.81, respectively.

---

[3] The RSN factor is 1.28 (see part 5 that follows).

[4] The January to September 1963 Isogram Maps were published in the May 1963 to January 1964 *Radiological Health Data*, respectively.

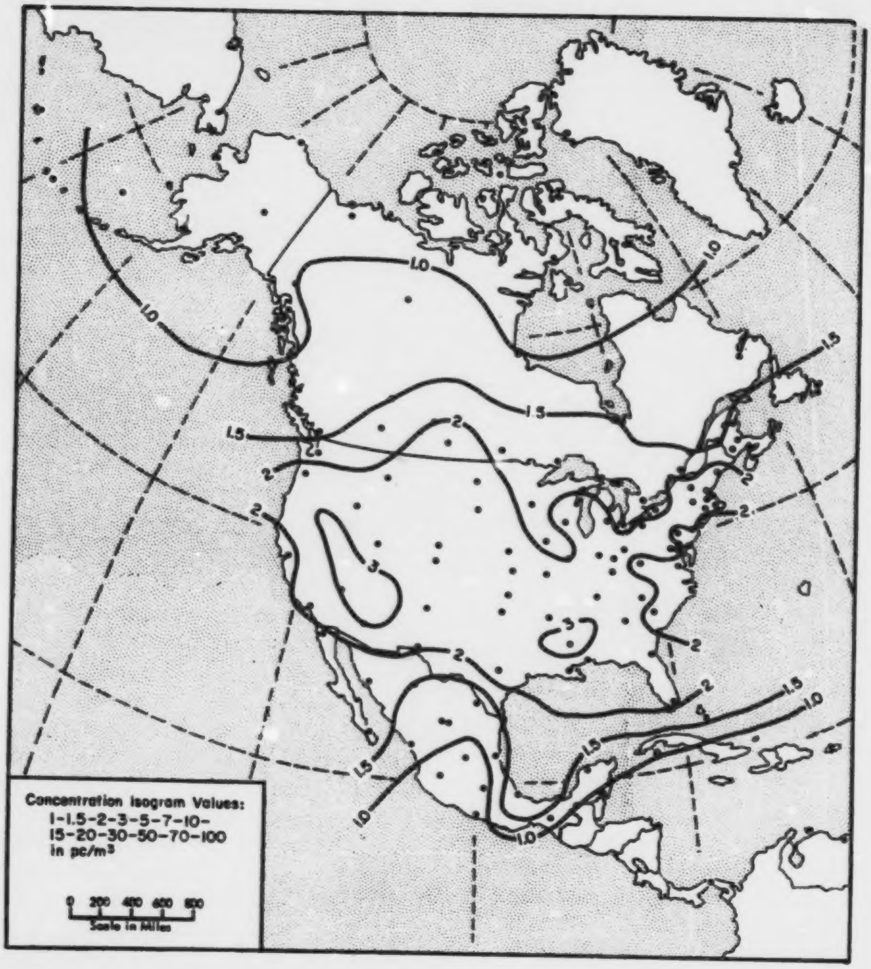

Concentration Isogram Values:
1-1.5-2-3-5-7-10-15-20-30-50-70-100 in pc/m³
0 200 400 600 800
Scale in Miles
1.0
1.5
2
3

FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, OCTOBER 1963

REFERENCES

(1) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73*:1318-30 (June 1, 1948).

(2) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D. C. 20201 (Distribution by official request.

(3) Bird, R. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(4) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(5) Mar, P. G.:*Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5*, Department of National Health and Welfare, Ottawa, Canada, (December 1962).

(6) Beale, J. and Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD-11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(7) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RPD-21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(8) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(9) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963), summarized in *Radiological Health Data*, January 1964.

FISSION PRODUCT GAMMA ACTIVITY IN AIRBORNE PARTICULATES—80TH MERIDIAN NETWORK, SEPTEMBER 1963

Health and Safety Laboratory, AEC

Total gamma activity measurements for weekly ground-level air filter samples taken at 80th Meridian stations (see figure 1) during September 1963 are listed in table 1. Calculated ratios of gamma activity in excess of 1 Mev to total gamma activity are also listed in the table. Average monthly total gamma activity concentrations calculated from the weekly values are plotted in figure 2 as an activity-latitude profile and compared with the profile for the third quarter 1963 average.

The September results as compared with those for July and August show a general decrease in ground-level air activity concentrations in the Northern Hemisphere but no major changes in the Southern Hemisphere. The average value of the northern sites was 1.1 $\gamma/min/m^3$ (photons per minute per cubic meter) with a range of from 0.080 to 2.1 $\gamma/min/m^3$. At stations in the Southern Hemisphere the average concentration was 0.10 with a range of from 0.029 to 0.17 $\gamma/min/m^3$.

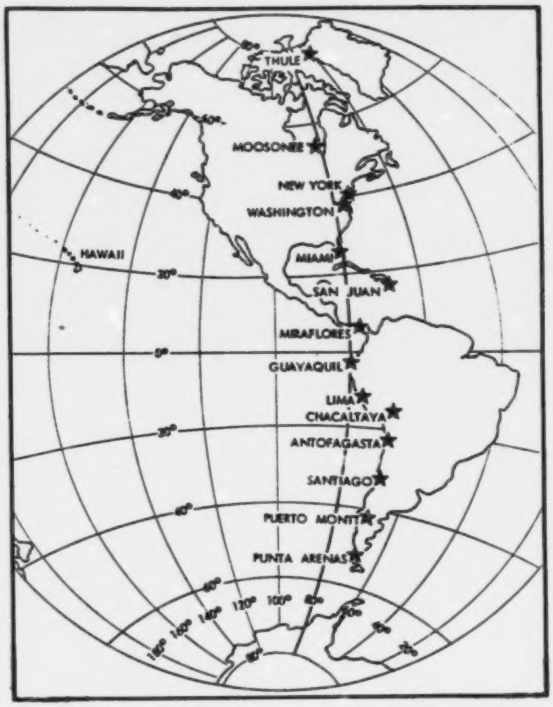


FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—GAMMA ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, SEPTEMBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio γ >1 Mev total γ
		Filter	Average for month	
Thule	9/1 -8	1.71		0.039
	9/8 -15	0.739		0.040
	9/15-22	0.836		0.036
	9/22-10/1	0.511	0.949	0.037
Moosonee	9/1 -8	1.56		0.039
	8/8 -15	1.05		0.045
	9/15-22	1.62		0.037
	9/22-10/1	1.43	1.42	0.045
New York	9/1 -8	3.65		0.047
	9/8 -15	1.43		0.047
	9/15-22	1.07		0.048
	9/22-10/1	1.47	1.91	0.046
Washington	9/1 -8	2.25		0.050
	9/8 -15	1.96		0.038
	9/15-22	1.99		0.049
	9/22-10/1	2.30	2.13	0.046
Miami	9/1 -8	2.20		0.045
	9/8 -15	1.02		0.045
	9/15-22	0.385		0.033
	9/22-10/1	0.503	1.03	0.048
Mauna Loa	9/1 -8	0.627		0.051
	9/8 -15	0.586		0.046
	9/15-22	0.679		0.050
	9/22-10/1	0.571	0.616	0.050
San Juan	9/1 -8	0.453		0.046
	9/8 -15	0.513		0.036
	9/15-22	0.440		0.047
	9/22-10/1	0.380	0.446	0.049
Miraflores	9/1 -8	0.101		0.050
	9/8 -15	0.110		0.048
	9/15-22	0.0734		0.060
	9/22-10/1	0.0347	0.0799	0.058
Guayaquil	9/1 -8	0.0967		0.042
	9/8 -15	0.0506		0.073
	9/15-22	0.0563		0.049
	9/22-10/1	0.0494	0.0632	0.084
Lima	9/1 -8	0.141		0.050
	9/8 -15	0.126		0.043
	9/15-22	0.0986		0.049
	9/22-10/1	0.170	0.134	0.043
Chacaltaya	9/1 -8	0.186		0.050
	9/8 -15	0.135		0.052
	9/15-22	0.214		0.052
	9/22-10/1	0.160	0.174	0.046
Antofagasta	9/1 -8	—[a]		—
	9/8 -15	0.123		0.054
	9/15-22	0.263		0.054
	9/22-10/1	0.109	0.165	0.047
Santiago	9/1 -8	0.0760		0.043
	9/8 -15	0.120		0.048
	9/15-22	0.0871		0.053
	9/22-10/1	0.0428	0.0815	0.045
Puerto Montt	9/1 -8	0.0135		0.049
	9/8 -15	0.0459		0.043
	9/15-22	0.0248		0.021
	9/22-10/1	0.0309	0.0287	0.048
Punta Arenas	9/1 -8	0.0410		0.088
	9/8 -15	0.0404		0.080
	9/15-22	—		—
	9/22-10/1	0.100	0.0606	0.038

[a] Dash indicates no sample.

55

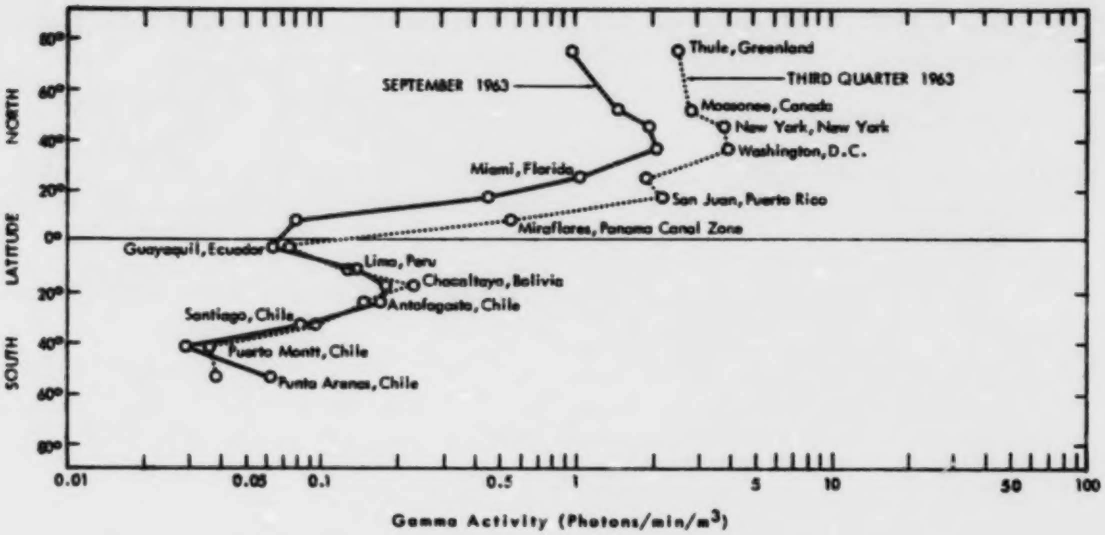


FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, THIRD QUARTER AND SEPTEMBER 1963

Total beta activity estimates are not given for the September samples because of the continued appearance of larger concentrations of high energy gamma emitters than would be expected in old mixed fission products. According to observations reported for thermally irradiated U^{235} (*1*) only about 1 percent of the total gamma activity in the September samples would be expected to be in excess of 1 Mev. The actual values average 4.5 percent and 5.2 percent for the Northern and Southern Hemispheres, respectively.

Although it will not be known until radiochemical determinations are complete, it is suspected that the major part of this discrepancy is caused by continued contributions from non-fission produced antimony-124 and possibly yttrium-88 activities. Also under investigation is the possibility that the analysis of fission product mixtures produced in the laboratory by thermal irradiation of uranium-235 (*1*) might underestimate the ruthenium-106 concentrations in fast neutron produced weapons debris. This might be a significant factor in the September ratios since Ru^{106} contributions are relatively large and since at least 10 percent of the Ru^{106} photons have energies in excess of 1 Mev.

REFERENCE

(*1*) Collins, W. R., Jr.: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, January 1963, *Radiological Health Data*, *4*: 342-6, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (July 1963).

MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section, fallout is defined as the deposition of radioactive materials on the earth's surface.

Total fallout is generally considered to be composed of two fractions: that deposited by the settling of particulates, often termed dry fallout, and that contained in precipitation, sometimes called wet fallout or rainout. Normally, fallout is expressed in terms of the activity of selected radionuclides deposited on a unit surface during a given period of time.

Monthly strontium-90 deposition during the first and second halves of 1962, collected by the Health and Safety Laboratory in the United States and other areas were reported in the August and October 1963 issues of *Radiological Health Data*, respectively. Deposition of other radionuclides at four stations was also reported. Deposition of various radionuclides in Canada during third quarter 1963 was reported in the January 1964 *Radiological Health Data.*

Fallout in the United States and Other Areas,[1] January-March 1963

Health and Safety Laboratory
Atomic Energy Commission

Monthy fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 40 sites in the United States and 93 locations in other countries. HASL data from 37 of the U. S. stations and 8 other selected points in the Western Hemisphere (see figure 1) covering the period from July 1962 through December 1962 are summarized below.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout for a period of one month are collected in stainless steel pots with exposed areas of 0.76m². At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample botle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.072m², attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT JANUARY—MARCH 1963

[Deposition in nc/m²]

Sampling location and type of collection			Jan	Feb	Mar
Ala:	Birmingham	(pot)	1.47	0.58	1.90
Alaska:	Anchorage	(col)	0.32	0.87	0.44
	Barrow	(col)	0.06	0.12	—
	Cold Bay	(col)	0.30	0.24	0.72
	Fairbanks	(col)	0.15	0.35	0.60
	Juneau	(col)	0.87	—	2.54
	Nome	(col)	0.67	—	—
Calif:	W. Los Angeles	(pot)	0.19	1.00	3.23
	Richmond	(col)	1.00	0.79	1.53
	Richmond	(pot)	0.98	0.97	2.19
	San Francisco	(col)	0.72	0.64	1.20
Colo:	Denver	(col)	0.08	—	0.22
Fla:	Coral Gables	(pot)	0.45	0.54	1.49
Hawaii:	Hilo	(col)	0.41	0.86	4.56
	Mauna Loa	(col)	0.32	0.15	0.84
	Oahu	(pot)	1.61	1.84	3.17
Ill:	Lemont	(pot)	0.24	0.11	2.45
Ky:	Louisville	(pot)	0.66	0.85	2.70
La:	New Orleans	(col)	0.60	0.62	0.25
Minn:	International Falls	(col)	0.20	0.15	0.26
Mo:	Columbia	(col)	0.15	0.18	0.76
Mont:	Helena	(col)	0.12	0.14	0.14
N. J:	Westwood	(pot)	1.00	1.04	2.43
	Westwood	(col)	0.99	0.90	1.48
N. Y:	New York	(pot)	0.92	0.44	1.64
N. Dak:	Williston	(col)	0.05	0.24	0.16
Okla:	Tulsa	(pot)	0.10	0.60	0.79
Ore:	Medford	(col)	0.95	0.61	0.39
Pa:	Pittsburgh	(pot)	0.79	0.90	2.83
	Pittsburgh	(col)	0.70	0.86	2.62
S. C:	Columbia	(col)	lost	0.67	1.06
S. Dak:	Vermillion	(pot)	0.10	0.17	1.76
Tex:	Dallas	(col)	0.15	0.30	0.39
	El Paso	(col)	0.13	0.23	0.03
	Houston	(col)	0.29	0.64	0.31
	Houston	(pot)	0.95	1.11	0.38
Va:	Sterling	(col)	0.49	0.93	1.68
Utah:	Salt Lake City	(pot)	[a]—	0.83	1.35
Wash:	Seattle	(pot)	0.74	1.17	1.52
	Tatoosh I.	(col)	0.34	2.44	—
Wis:	Green Bay	(col)	0.21	0.06	1.27
Greenland:	Thule	(col)	0.03	0.06	0.00
Iceland:	Keflavik	(col)	0.73	0.80	1.15
Newfoundland:	Goose A. B.	(col)	0.37	0.12	0.27
	E. Harmon AB	(col)	0.33	0.08	0.28
Bermuda:	Kindley AFB	(col)	0.18	0.13	0.78
Puerto Rico:	San Juan	(col)	0.34	0.24	1.79
Mexico:	Mexico City	(col)	0.01	0.02	0.03
Costa Rica:	Turrialba	(col)	0.00	0.24	0.55
Panama Canal Zone		(col)	0.14	0.14	0.03

[a] Dash indicates sample or analysis not received.

---

[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL-142* (January 1, 1964).

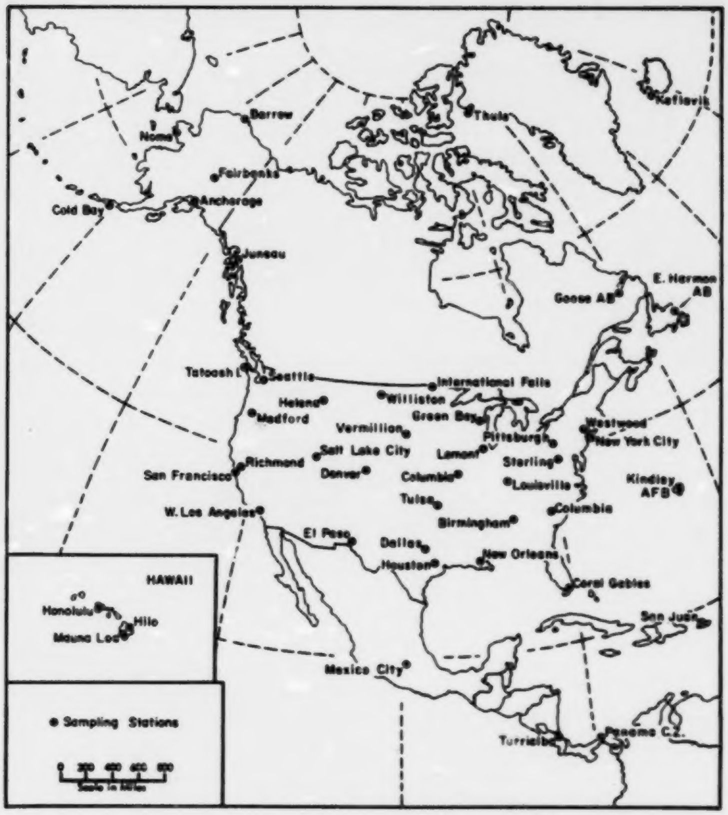

Kefiavik
Thule
Barrow
Nome
Fairbanks
Cold Bay
Anchorage
Juneau
Goose AB
E. Harmon AB
Tatoosh I.
Seattle
International Falls
Helena
Williston
Medford
Green Bay
Westwood
Vermillion
Pittsburgh
New York City
Salt Lake City
Lemont
Sterling
Richmond
San Francisco
Denver
Columbia
Louisville
Kindley AFB
Tulsa
W. Los Angeles
Columbia
Birmingham
El Paso
Dallas
New Orleans
Houston
Coral Gables
HAWAII
Honolulu
Hilo
Mauna Loa
San Juan
Mexico City
Sampling Stations
Scale in Miles
Turrialba
Panama C.Z.

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

Strontium-90

All of the HASL fallout samples—both pot and column were assayed for strontium-90 and the ratio of strontium-89 to strontium-90. The strontium-90 data are given in table 1 for the 45 selected stations. Where duplicate samples were collected, the average values are given.

Other Radionuclides

Laboratories at Richmond, California; Westwood, New Jersey; Pittsburgh, Pennsylvania; and Houston, Texas, have analyzed duplicate monthly collections for various radionuclides. The monthly deposition rates for Zr^{95}, Cs^{137}, and Ba^{140}, as well as the Sr^{89}/Sr^{90} ratio and precipitation depth, are presented in table 2. The strontium-90 values for these stations are included in table 1.

TABLE 2.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES JANUARY—MARCH 1963

Location and analyses	January	February	March
California, Richmond			
Precipitation (mm)	113	54	101
Sr^{89}/Sr^{90} ratio	28	22	16
Zr^{95} (nc/m²)	41.9	27.3	52
Cs^{137} (nc/m²)	1.62	1.60	3.9
Ba^{140} (nc/m²)	[a]—	—	—
New Jersey, Westwood			
Precipitation (mm)	53	30	102
Sr^{89}/Sr^{90} ratio	28	19	12
Zr^{95} (nc/m²)	48.5	28.0	48.1
Cs^{137} (nc/m²)	1.48	1.33	3.54
Ba^{140} (nc/m²)	—	—	—
Pennsylvania, Pittsburgh			
Precipitation (mm)	50	65	174
Sr^{89}/Sr^{90} ratio	28	23	14
Zr^{95} (nc/m²)	27.6	22.4	43.4
Cs^{137} (nc/m²)	1.23	1.51	5.02
Ba^{140} (nc/m²)	—	—	—
Texas, Houston			
Precipitation (mm)	78	44	14
Sr^{89}/Sr^{90} ratio	31	22	8.9
Zr^{95} (nc/m²)	28.5	32.1	9.7
Cs^{137} (nc/m²)	Lost	2.08	0.77
Ba^{140} (nc/m²)	—	—	—

[a] Dash indicates sample not analyzed for nuclide indicated.

REFERENCE

(*1*) Ong, L. D. Y., Homogeneity Between Pot and Ion Exchange Column Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL-135:* 256-69, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $4.00.

Section II.—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, October 1963

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. More milk sampling points continued to be added until July 1962. With the addition of the Canal Zone station in October 1963, the number of stations now stands at 63.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Complete analytical results are available 6 to 7 weeks after collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

59

Analytical Errors

Iodine-131, cesium-137 and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, a two-week composite is analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. The minimum detectable concentration is defined as the measured concentration at which the statistical two-standard-deviation analytical error is 100 percent (*1*). Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 1; Cs^{137}, 5; Ba^{140}, 10; and I^{131}, 10.

Calcium analyses at SERHL and NERHL are done by an ion exchange and volumetric method while at SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum.

Data Presentation

Table 1 presents summaries of the analyses for October 1963 (September 29-October 26, 1963). Although not shown in table 1, the iodine-131 and barium-140 monthly average concentrations in milk were <10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with the October 1963 data, however, zero has been used as the best approximation to a nondetectable concentration of iodine-131 or barium-140. A similar procedure is used for the network average.

Figures 1, 2, and 3 are isoconcentration maps showing the estimated strontium-89, strontium-90, and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentra-

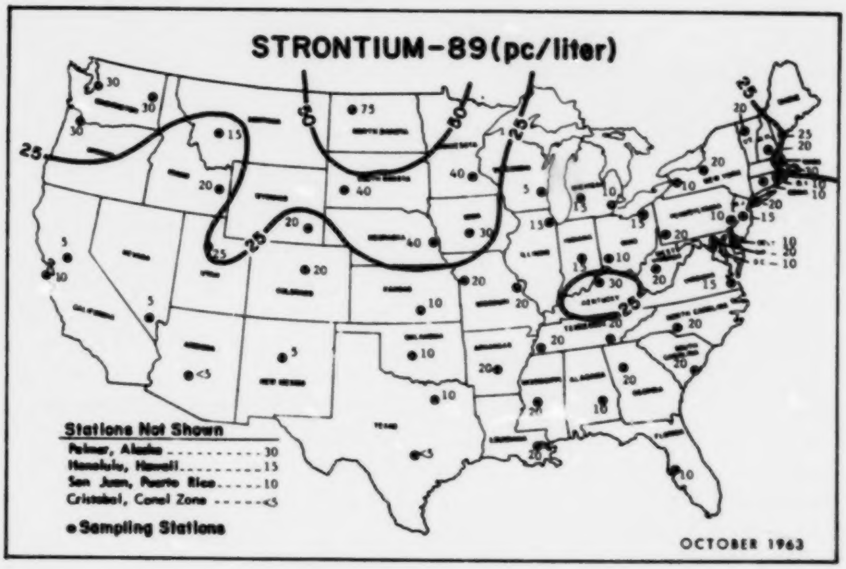

STRONTIUM-89(pc/liter)
25
50
80
25
25
25
25
Stations Not Shown
Palmer, Alaska 30
Honolulu, Hawaii 15
San Juan, Puerto Rico 10
Cristobal, Canal Zone ..... <5
● Sampling Stations
OCTOBER 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

---

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 1.—RADIOACTIVITY IN PASTEURIZED MILK, OCTOBER 1963[a]

(Average radioactivity concentrations in pc/liter)

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	RHD
Ala:	Montgomery	1.17	1.20	1.4	1.4	45	10	21	19	85	80	Oct. 63
Alaska:	Palmer	1.17	1.22	1.5	1.6	45	30	24	34	160	175	Nov. 63
Ariz:	Phoenix	1.14	1.12	1.7	1.7	5	< 5	3	2	25	30	Jan. 64
Ark:	Little Rock	1.19	1.21	1.3	1.5	105	20	44	36	170	110	Nov. 63
Calif:	Sacramento	1.18	1.18	1.6	1.7	10	5	9	8	50	55	Dec. 63
	San Francisco	1.17	1.28	1.6	1.8	20	10	9	6	65	60	Feb. 64
C. Z.:	Cristobal	b	1.11	b	1.4	b	< 5	b	4	b	30	b
Colo:	Denver	1.18	1.16	1.6	1.7	40	20	22	17	110	80	Dec. 63
Conn:	Hartford	1.16	1.20	1.6	1.6	40	10	31	24	215	155	Dec. 63
Del:	Wilmington	1.18	1.19	1.6	1.7	35	10	30	24	150	120	Jan. 64
D. C:	Washington	1.13	1.16	1.5	1.5	45	10	21	16	110	70	Feb. 64
Fla:	Tampa	1.19	1.18	1.4	1.5	25	10	14	16	275	285	Jan. 64
Ga:	Atlanta	1.18	1.21	1.4	1.5	75	20	33	29	190	120	Feb. 64
Hawaii:	Honolulu	1.18	1.09	1.6	1.7	15	15	12	13	85	95	Nov. 63
Idaho:	Idaho Falls	1.17	1.17	1.5	1.7	60	20	33	20	160	145	Jan. 64
Ill:	Chicago	1.21	1.19	1.6	1.7	30	15	23	16	125	95	Feb. 64
Ind:	Indianapolis	1.19	1.23	1.6	1.5	40	15	24	22	110	75	Dec. 63
Iowa:	Des Moines	1.18	1.16	1.5	1.6	50	30	28	23	85	85	Jan. 64
Kans:	Wichita	1.16	1.14	1.5	1.7	35	10	24	12	80	65	Nov. 63
Ky:	Louisville	1.14	1.14	1.4	1.6	100	30	39	27	125	75	Jan. 64
La:	New Orleans	1.21	1.26	1.4	1.5	80	20	41	39	160	140	Nov. 63
Maine:	Portland	1.18	1.20	1.6	1.6	55	25	38	36	300	240	Jan. 64
Md:	Baltimore	1.14	1.15	1.4	1.4	60	20	25	20	145	95	Jan. 64
Mass:	Boston	1.18	1.18	1.6	1.6	70	30	47	35	320	240	Feb. 64
Mich:	Detroit	1.17	1.20	1.6	1.6	30	10	22	20	130	105	Dec. 63
	Grand Rapids	1.18	1.23	1.6	1.6	35	15	22	23	145	120	Jan. 64
Minn:	Minneapolis	1.17	1.16	1.5	1.6	70	40	34	26	170	140	Feb. 64
Miss:	Jackson	1.22	1.22	1.4	1.4	80	20	36	34	125	95	Dec. 63
Mo:	Kansas City	1.15	1.15	1.6	1.6	55	20	29	29	75	80	Dec. 63
	St. Louis	1.16	1.18	1.5	1.7	45	20	25	18	85	70	Nov. 63
Mont:	Helena	1.16	1.16	1.4	1.6	80	15	39	32	245	175	Nov. 63
Nebr:	Omaha	1.17	1.12	1.6	1.6	50	40	29	24	100	90	Jan. 64
Nev:	Las Vegas	1.16	1.21	1.6	1.8	20	5	12	7	90	80	Feb. 64
N. H:	Manchester	1.20	1.22	1.6	1.6	60	20	43	39	355	270	Jan. 64
N. J:	Trenton	1.16	1.20	1.6	1.6	30	15	26	19	160	115	Dec. 63
N. Mex:	Albuquerque	1.12	1.18	1.6	1.7	20	5	12	11	50	45	Nov. 63
N. Y:	Buffalo	1.16	1.20	1.7	1.7	40	10	26	23	170	130	Dec. 63
	New York	1.14	1.20	1.6	1.7	60	20	41	32	225	160	Feb. 64
	Syracuse	1.19	1.20	1.6	1.7	45	20	31	23	165	140	Nov. 63
N. C:	Charlotte	1.17	1.16	1.4	1.6	80	20	35	30	155	100	Nov. 63
N. Dak:	Minot	1.16	1.16	1.5	1.6	130	75	60	54	170	135	Jan. 64
Ohio:	Cincinnati	1.20	1.21	1.6	1.6	40	10	28	22	95	70	Dec. 63
	Cleveland	1.16	1.21	1.6	1.7	40	15	24	20	125	90	Nov. 63
Okla:	Oklahoma City	1.13	1.14	1.4	1.5	55	10	22	18	90	65	Feb. 64
Ore:	Portland	1.22	1.18	1.4	1.6	50	30	33	29	190	175	Dec. 63
Pa:	Philadelphia	1.15	1.22	1.6	1.7	35	10	26	21	140	110	Nov. 63
	Pittsburgh	1.20	1.20	1.6	1.6	60	20	36	26	190	130	Nov. 63
P. R:	San Juan	1.14	1.14	1.4	1.5	35	10	14	12	95	60	Nov. 63
R. I:	Providence	1.19	1.22	1.7	1.6	45	10	35	28	225	165	Jan. 64
S. C:	Charleston	1.17	1.20	1.4	1.5	60	20	26	26	150	120	Dec. 63
S. Dak:	Rapid City	1.07	1.12	1.5	1.6	100	40	49	32	175	140	Feb. 64
Tenn:	Chattanooga	1.20	1.24	1.4	1.5	110	20	46	32	185	110	Feb. 64
	Memphis	1.18	1.19	1.4	1.5	75	20	33	27	100	60	Jan. 64
Tex:	Austin	1.14	1.20	1.5	1.5	20	< 5	10	8	55	35	Feb. 64
	Dallas	1.16	1.18	1.5	1.6	40	10	19	17	75	60	Dec. 63
Utah:	Salt Lake City	1.13	1.22	1.5	1.7	55	25	30	20	205	155	Nov. 63
Vt:	Burlington	1.16	1.21	1.6	1.6	55	20	39	27	245	185	Dec. 63
Va:	Norfolk	1.15	1.15	1.4	1.4	45	15	23	21	115	80	Dec. 63
Wash:	Seattle	1.20	1.18	1.5	1.7	55	30	36	29	205	185	Feb. 64
	Spokane	1.22	1.20	1.5	1.8	55	30	30	34	160	145	Dec. 63
W. Va:	Charleston	1.13	1.17	1.4	1.3	85	20	34	25	120	75	Feb. 64
Wis:	Milwaukee	1.24	1.28	1.8	1.8	30	5	21	18	130	110	Jan. 64
Wyo:	Laramie	1.15	1.16	1.5	1.6	45	20	27	20	125	125	Jan. 64
Network average		1.17	1.19	1.5	1.6	52	18	28.4	23.1	147	115	

[a] The monthly average iodine-131 and barium-140 concentration at each station was < 10 pc/liter.

[b] Station began operation in October 1963.

tion for that station. The isoconcentration maps were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isoconcentration contours are made according to available information on milksheds. In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 2 has been prepared using monthly average data shown in table 1.

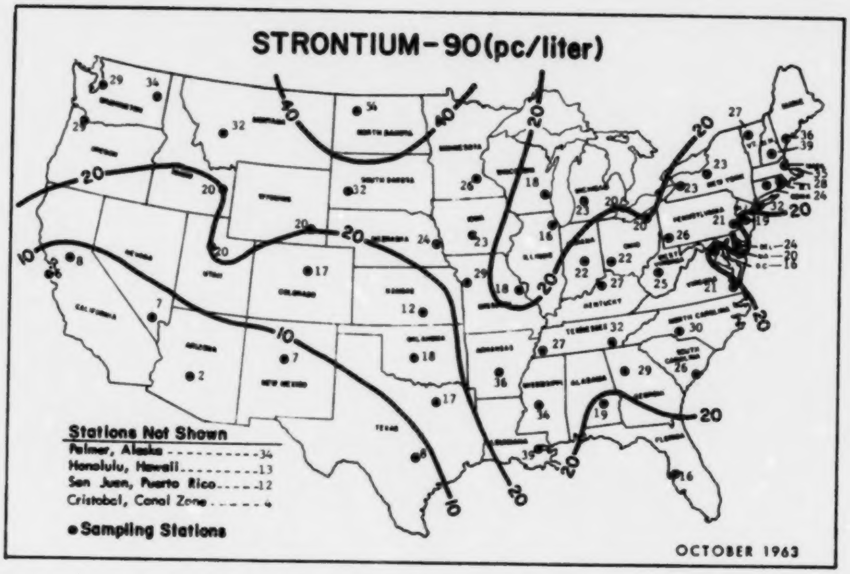

STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska ---------- 34
Honolulu, Hawaii ---------- 13
San Juan, Puerto Rico ----- 12
Cristobal, Canal Zone ----- 4
● Sampling Stations
OCTOBER 1963
10
20
40

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

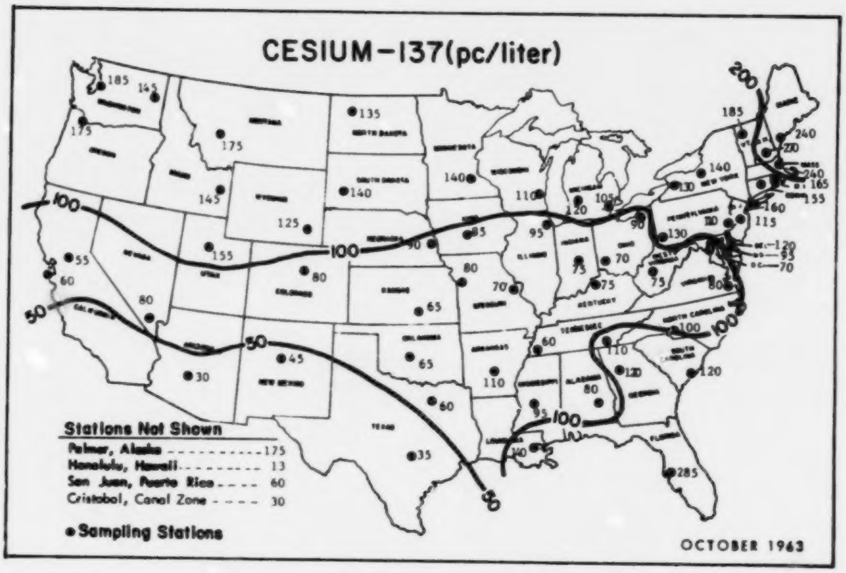

CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska ---------- 175
Honolulu, Hawaii ---------- 13
San Juan, Puerto Rico ----- 60
Cristobal, Canal Zone ----- 30
● Sampling Stations
OCTOBER 1963
50
100
200

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

Continuing the practice followed in previous issues of *Radiological Health Data*, the average monthly strontium-90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network at least twice a year.

TABLE 2.—DISTRIBUTION OF SAMPLING STATIONS ACCORDING TO RADIONUCLIDE CONCENTRATIONS IN MILK, OCTOBER 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
< 5–5	7	< 1–4	2	< 10	63	< 5–45	4	< 10	63
10	15	5–9	4			50–95	25		
15	8	10–14	4			100–145	21		
20	20	15–19	10			150–195	9		
25	2	20–24	17			200–245	2		
30	7	25–29	12			250–295	2		
35	0	30–34	8						
40	3	35–39	5						
>40	1	>39	1						

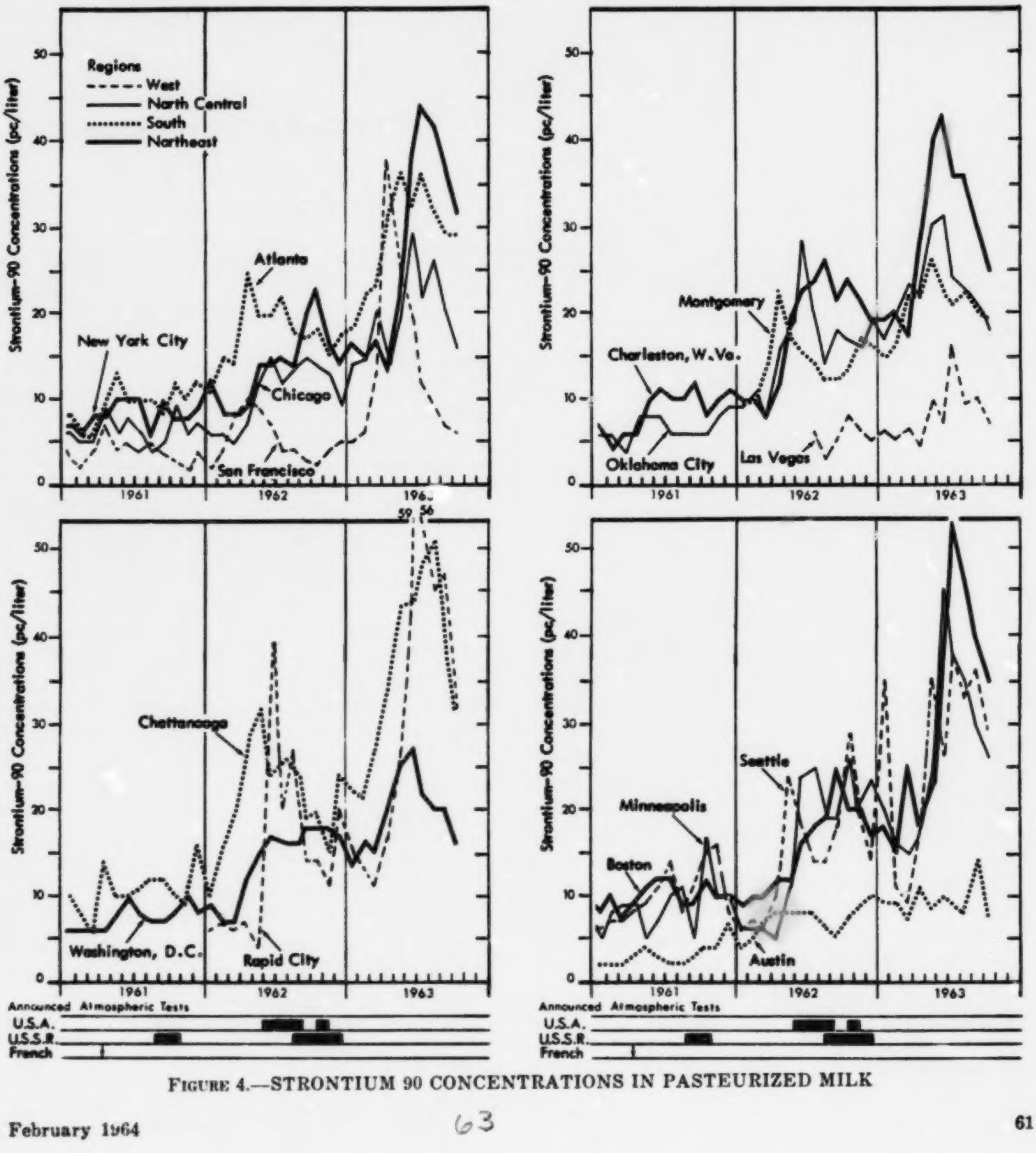


FIGURE 4.—STRONTIUM 90 CONCENTRATIONS IN PASTEURIZED MILK

2. Indiana Milk Network, October 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

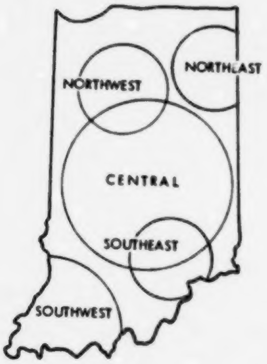


FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89 and strontium-90. Until August 1963, analyses for the gamma emitters iodine-131, cesium-137 and barium-140 were conducted on a weekly basis, except when iodine-131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentration of the short half-life gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium-89 and strontium-90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*2*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131, cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 3. The State average is an arithmetic average of the station values.

TABLE 3.—RADIONUCLIDES IN INDIANA MILK, OCTOBER 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	0	22	< 10	110	< 10
Southeast	30	16	< 10	85	< 10
Central	0	23	< 10	70	< 10
Southwest	15	13	< 10	60	< 10
Northwest	20	14	< 10	95	< 10
State average	15	18	< 10	85	< 10

3. New York Milk Network, September 1963

Division of Environmental Health Services
State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 6)—are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, cesium-137 and barium-lanthanum-140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once per week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*3*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium)

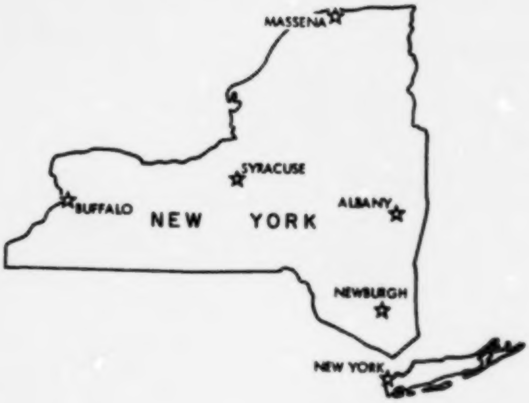


FIGURE 6.—NEW YORK MILK SAMPLING LOCATIONS

are eluted from the ion exchange resin with sodium chloride solution, strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylene-diaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 4.

TABLE 4.—RADIONUCLIDES IN NEW YORK MILK, SEPTEMBER 1963

[Average concentrations in pc/liter]

Sampling locations	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	$Ba\text{-}La^{140}$
Albany	30	26	<20	108	<20
Buffalo	28	18	<20	96	<20
Massena	44	22	<20	193	<20
Newburgh	25	30	<20	82	<20
New York City	33	31	<20	126	<20
Syracuse	24	23	<20	85	<20
Average	31	25	<20	115	<20

Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

4. Oregon Milk Network, July-October 1963

Division of Sanitation & Engineering
Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 7.

The half-gallon samples of packaged milk are collected on a monthly basis Statewide by the Oregon Department of Agriculture and weekly in the Portland area by the City of Portland. Milk sampling frequency is accelerated to a weekly schedule at those locations having radionuclide concentrations in milk in excess of 100 pc/liter for iodine-131 or 500 pc/liter for cesium-137 (suggestive of elevated strontium-90 concentrations). The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine-131, cesium-137, barium-140, and strontium-90 analyses. Gamma analysese are preformed utilizing a 3" x 3" sodium dure (4). The minimum detectable concentra- iodide scintillation detector with a 512-channel pulse-height analyzer system. Samples are normally counted for 100 minutes. The strontium190 analyses are done by an ion exchange procedure (4). The minimum detectable concentrations are iodine-131, cesium-137, and barium-140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, will exceed the background by 3σ (counting error) of the background.

Table 5 presents the Oregon milk surveillance data for the period July through October 1963.

TABLE 5.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, JULY—OCTOBER 1963[a]

[Average concentrations in pc/liter]

Sampling location & frequency	Nuclide	Jul	Aug	Sep	Oct
Baker (monthly)	I^{131}	30	<15	<15	<15
	Cs^{137}	240	260	150	110
Coos Bay (monthly)[b]	I^{131}	<15	<15	<15	<15
	Cs^{137}	225	120	50	70
Eugene (monthly)	I^{131}	<15	<15	<15	<15
	Cs^{137}	195	95	105	130
Medford (monthly)	I^{131}	<15	<15	<15	<15
	Cs^{137}	135	90	70	65
Nyssa (monthly)	I^{131}	<15	<15	<15	[c]20
	Cs^{137}	210	95	85	120
Portland (Composite weekly)	I^{131}	15	<15	<15	<15
	Cs^{137}	200	190	215	170
Portland (Local producer)	I^{131}	<15	<15	<15	<15
	Cs^{137}	195	160	140	145
Redmond (monthly)	I^{131}	<15	<15	<15	[c]30
	Cs^{137}	205	180	145	160
Tillamook (monthly)[b]	I^{131}	<15	<15	<15	[c]20
	Cs^{137}	320	220	365	285

[a] Barium-140 average concentrations were <15 pc/liter at each station during this period.

[b] May—August weekly.

[c] Unidentified interfering radionuclides may have produced these results.

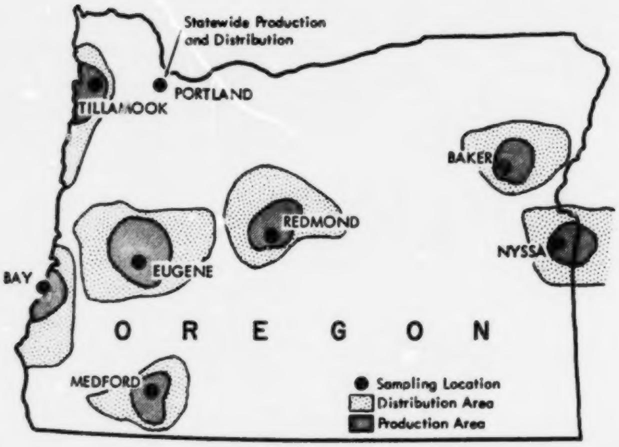
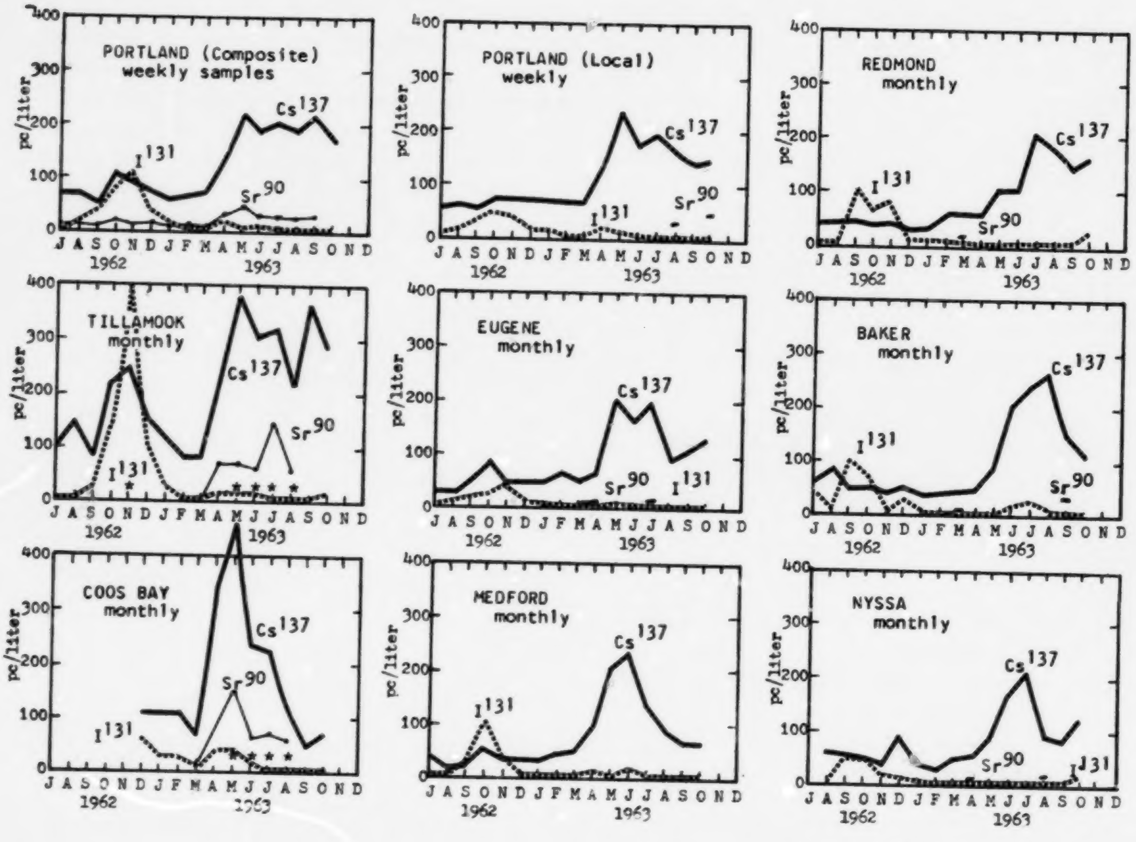

Statewide Production and Distribution
PORTLAND
TILLAMOOK
BAKER
REDMOND
NYSSA
COOS BAY
EUGENE
O R E G O N
MEDFORD
Sampling Location
Distribution Area
Production Area

FIGURE 7.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS



* Special weekly sampling

FIGURE 8.—RADIONUCLIDES IN OREGON MILK

TABLE 6.—STRONTIUM-89 AND STRONTIUM-90 IN OREGON MILK, MARCH—AUGUST 1963

[Average concentrations in pc/liter]

Sampling location [a]	Strontium-89						Strontium-90					
	Mar.	Apr.	May	Jun.	July	Aug.	Mar.	Apr.	May	Jun.	July	Aug.
Coos Bay	—	—	855	310	225	100	[b]16	—	147	63	73	60
Portland (composite)	55	140	210	150	80	25	12	29	48	36	34	32
Tillamook	—	—	395	245	310	90	[b]10	[b]72	72	60	143	60

[a] Locations shown have regular radiostrontium analyses. Other stations in the network presently have radiostrontium analyzed on a random basis.
[b] Analyzed by Oregon State Board of Health. Other analyses performed by Public Health Service.

Table 6 shows radiostrontium results for March through August 1963. Through reanalysis of some samples the data in this table supersedes that previously published (*5*). Figure 8 shows iodine–131, cesium–137 and strontium–90 concentrations for all sampling locations. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in southern Washington. Thus, it tends to represent a State average.

Previous coverage in *Radiological Health Data:*

Period	Issue
July-October 1962	*January 1963*
November 1962-February 1963	*May 1963*
March-June 1963	*September 1963*

5. Canadian Milk Network,[2] October 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137 and strontium–90 as well as table potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

Analytical Methods

For the analysis of iodine–131, radiochemical methods (*6*) are used. Carrier iodine is added

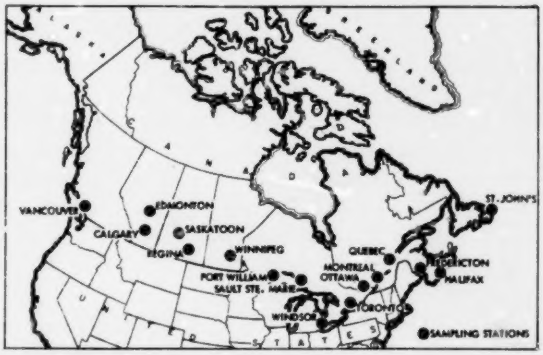


FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodine ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodine. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

---

[2] Data from *Radiation Protection Programs, Vol. 1, No. 11*:25-30, Radiation Protection Division, Canadian Department of National Health and Welfare. (November 1963).

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with a polyethylene sheet. The residue is ashed in a muffle furnace at 450° C, dissolved in dilute nitric acid, and strontium is separated on an ion-exchange column (*7, 8*). The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter isotope, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodine crystal detector. The sample is counted for 100 minutes and the gamma spec- potassium–40 and cesium–137 content of the potassium–40 and cessium–137 content of the milk by comparison of the spectrum with standard prepartions.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier." In the determiniation of cesium this factor is not involved.

The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in reference (*9*). For example, the 2_σ total errors (representing 95 percent confidence) associated with a measured concentration of 10 pc/liter, in units of pc/liter are Sr^{89}, 2.5; Sr^{90}, 1.5; I^{131}, 5; and Cs^{137}, 6.

Results

Table 7 presents monthly averages of strontium–89, strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 indicate that all stations had <5 pc/liter. Figures 10 and 11 show the variation of the network average of the radionuclides content of Canadian whole milk.

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*10*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a life-

TABLE 7.—RADIONUCLIDES IN CANADIAN WHOLE MILK, OCTOBER 1963

[Radionuclide concentration in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89	Strontium-90	Cesium-137
Calgary	1.35	1.4	33	48	198
Edmonton	1.33	1.5	23	30	187
Ft. William	1.22	[illegible]	37	53	227
Fredericton	1.26	1.4	37	64	307
Halifax	1.28	1.5	40	50	236
Montreal	1.33	1.6	46	45	194
Ottawa	1.28	1.6	26	36	168
Quebec	1.34	1.5	42	66	282
Regina	1.30	1.6	29	45	125
St. John's, Nfld.	1.38	1.6	39	65	276
Saskatoon	1.31	1.5	46	48	150
Sault Ste. Marie	1.27	1.6	31	48	187
Toronto	1.22	1.5	17	19	123
Vancouver	1.33	1.5	34	47	342
Windsor	1.20	1.4	11	16	61
Winnipeg	1.29	1.5	44	40	187
Average	1.29	1.5	33	45	203

68

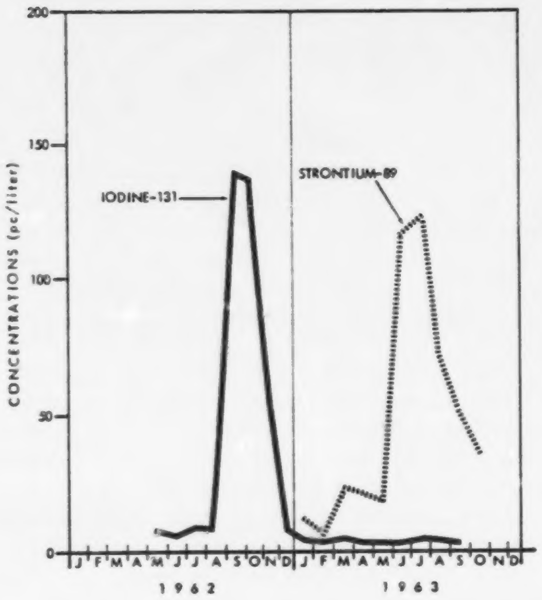


Figure 10.—IODINE-131 AND STRONTIUM-89 CONCENTRATIONS IN CANADIAN WHOLE MILK

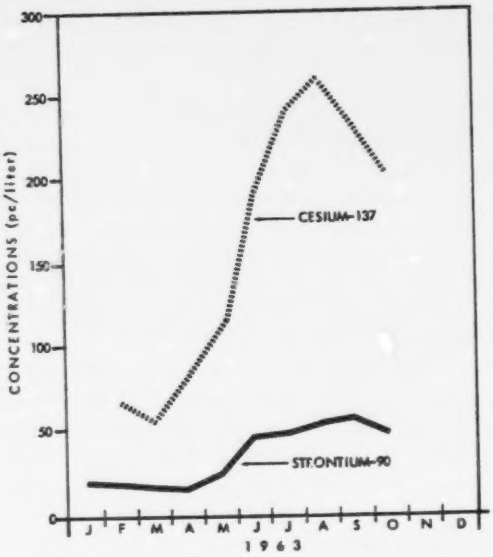


Figure 11.—STRONTIUM-90 AND CESIUM-137 CONCENTRATION IN CANADIAN WHOLE MILK

time. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

REFERENCES

(1) Public Health Service: Pasteurized Milk Network, February 1963, *Radiological Health Data, 4*:291-6, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (June 1963).

(2) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determinations of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306-8 (September 1961).

(3) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999-R-2*, (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

(4) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*:1306-8 (September 1961).

(5) Oregon State Board of Health; Oregon Milk Network, March-June 1963, *Radiological Health Data 4*: 461-2, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1963).

(6) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, (October 1963).

(7) Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada: *The Preliminary Report on the Measurement of Radioactive Strontium in Canadian Milk Powder Samples, CNHW-RP-1*. (July 1958).

(8) Mar, Peter G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powders for Strontium and Yttrium, RPD-5*, Radiation Protection Division, Department of National Health and Welfare, (June 1, 1960).

(9) Public Health Service: Canadian Milk Network, *Radiological Health Data 4*:561-3, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (November 1963).

(10) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, NOVEMBER 1962-OCTOBER 1963

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) may be used to assess that portion of an individual's or a population's radiation dose attributable to milk consumption by determining both the annual average concentrations of specific radionuclides of interest in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

Assuming that the average daily milk consumption of an individual in a population group is one liter comparisons can be made between the daily rates of intake of the above radionuclides from the milk component of the diet and the Federal Radiation Council's action ranges of transient daily rates of intake (*4*). The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in 12 consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1) obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance-Pasteurized Milk Network, Radiological Health Data, 4:19-23, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (January 1964).

(*2*) Bureau of the Census, Department of Commerce, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* 4:15-17, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (January 1964).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data* 4:124-7, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402, (March 1963.)

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: Background Material for the Development of Radiation Protection Standards, Report No. 2, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961). Price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, 3:ii-iii, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 1962).

---

[1] Beginning with October 1963 data, iodine-131 values of <10 pc/liter are considered zero for averaging purposes; previously, <5 pc/liter was used in calculating averages.

70

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK [a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		October 1962—September 1963	November 1962—October 1963	October 1962—September 1963	November 1962—October 1963	October 1962—September 1963	November 1962—October 1963	October 1962—September 1963	November 1962—October 1963
Ala:	Montgomery	68	67	19	20	15	14	63	68
Alaska:	Palmer	46	37	16	17	32	11	86	95
Ariz:	Phoenix	18	15	4	4	9	8	20	20
Ark:	Little Rock	139	135	40	40	36	32	133	138
Calif:	Sacramento	42	42	9	9	10	9	48	51
	San Francisco	75	75	12	12	9	9	58	61
Colo:	Denver	27	27	15	15	10	8	76	78
Conn:	Hartford	29	26	19	20	14	9	118	125
Del:	Wilmington	39	36	23	23	24	19	106	111
D. C:	Washington	46	43	19	19	17	13	85	87
Fla:	Tampa	37	36	13	13	18	17	184	196
Ga:	Atlanta	94	93	26	27	22	20	120	126
Hawaii:	Honolulu	37	37	9	10	11	11	61	66
Idaho:	Idaho Falls	45	45	20	20	14	11	106	112
Ill:	Chicago	28	24	18	18	20	10	89	92
Ind:	Indianapolis	39	35	20	21	23	16	82	84
Iowa:	Des Moines	72	66	22	22	31	22	75	78
Kans:	Wichita	52	48	18	17	23	19	65	67
Ky:	Louisville	104	101	30	30	23	20	89	93
La:	New Orleans	149	147	37	38	26	24	129	136
Maine:	Portland	35	31	25	27	15	11	159	169
Md:	Baltimore	53	51	20	20	17	13	105	107
Mass:	Boston	41	36	29	30	15	8	170	180
Mich:	Detroit	26	21	19	19	21	12	93	96
	Grand Rapids	24	22	17	18	18	11	94	99
Minn:	Minneapolis	59	53	26	26	21	13	127	130
Miss:	Jackson	148	147	31	32	25	23	93	98
Mo:	Kansas City	86	80	23	24	34	27	68	71
	St. Louis	57	54	19	20	19	14	71	74
Mont:	Helena	54	51	23	24	25	19	132	139
Nebr:	Omaha	58	56	22	23	29	23	76	85
Nev:	Las Vegas	20	19	8	7	7	6	55	59
N. H:	Manchester	38	33	27	28	14	9	189	202
N. J:	Trenton	30	26	19	20	17	13	99	103
N. Mex:	Albuquerque	25	24	8	8	11	10	35	36
N. Y:	Buffalo	29	24	20	20	13	6	111	116
	New York	39	34	25	25	22	12	121	127
	Syracuse	32	27	21	21	16	8	101	107
N. C:	Charlotte	74	72	28	29	9	8	100	104
N. Dak:	Minot	87	85	40	42	18	10	113	118
Ohio:	Cincinnati	48	45	23	24	27	21	72	76
	Cleveland	33	29	19	19	21	14	88	91
Okla:	Oklahoma City	77	75	22	22	31	29	77	80
Ore:	Portland	104	98	25	26	20	15	124	131
Pa:	Philadelphia	36	33	22	22	22	17	100	105
	Pittsburgh	44	41	25	26	31	22	121	125
P. R:	San Juan [b]	88	87	14	14	15	15	87	89
R. I:	Providence	34	31	24	24	18	12	128	135
S. C:	Charleston	74	73	24	25	18	16	104	108
S. Dak:	Rapid City	71	70	28	30	22	16	115	121
Tenn:	Chattanooga	120	118	33	33	19	17	117	122
	Memphis	106	103	29	29	25	22	76	78
Tex:	Austin	39	39	9	9	30	30	41	42
	Dallas	92	90	20	20	47	45	71	74
Utah:	Salt Lake City	36	36	18	19	15	10	122	127
Vt:	Burlington	36	31	23	24	17	10	132	140
Va:	Norfolk	53	51	21	21	15	12	90	92
Wash:	Seattle	77	71	23	23	19	15	128	135
	Spokane	54	53	21	23	13	10	112	117
W. Va:	Charleston	76	72	28	28	14	11	85	87
Wis:	Milwaukee	28	24	16	16	25	14	90	94
Wyo:	Laramie	46	43	19	19	8	5	106	109
Network average		58	55	21.4	21.8	20	15	98	103

[a] Annual averages were computed on basis of 52 weekly averages.

[b] Average is for 48 weeks (No sample was received in November 1962).

71

EFFECT OF THE EVAPORATION AND POWDERING PROCESSES ON THE IODINE-131 CONTENT OF MILK

Allan E. Raymond and George W. Williams[1]

The National Advisory Committee on Radiation has stated that: "One of the first countermeasures to consider against iodine–131 is the placing of all children of early age, lactating mothers and pregnant women on evaporated milk or powdered dry skim milk (*1*)." This proposed countermeasure assumes an average transit time of at least two months for the milk to reach the consumer in order to allow for a decrease in iodine–131 activity due to radioactive decay.

To determine what problems might be involved if such public health action were ever warranted, the New York State Department of Health undertook a limited investigation of iodine–131 in evaporated and powdered milk. The investigation was primarily directed towards determining to what extent the total amount of iodine–131 contained in the raw milk may be altered as the milk is processed into evaporated or powdered milk. The second purpose of the investigation was to briefly review the marketing practices involved with these two milk products. A literature search revealed no information on the removal of iodine–131 during the processing of evaporated and powdered milk. However, a somewhat related study was reported by Dubrovina and Belova on the progression of strontium–90 from whole milk to various milk products (*2*). Also, a laboratory study by Demott and Easterly has shown that iodine–131 is not volatile when milk is heated to 70° C in a vacuum of 23-25 inches of mercury (*3*).

The procedures followed and the results secured from the investigation are summarized below.

Sampling Procedures

Two sets of samples were collected for analysis. One set was obtained from an evaporated milk plant on September 28, 1962, and the other from a powdered milk plant on October 3, 1962. Each set consisted of single samples of milk from specific points in the manufacturing process. The same increment of milk input was sampled as it progressed through the manufacturing process at each plant.

The milk samples were analyzed[2] within 24 hours and extrapolated to time of collection. The analyses for iodine–131 were made with a 512-channel gamma spectrometer using a 4"x 4" sodium iodide crystal. Quantitative analysis from the gamma spectrum was made by the "matrix method."

Evaporated Milk Process and Sampling Results

The following outline lists the sequence of steps in the manufacture of evaporated milk.

1E. Raw milk weighing, sampling and inspection
2E. Heating in hot wells (for stability)
3E. Vacuum pan evaporation of heated milk
4E. Filtration (cotton filters)
5E. Homogenization
6E. Cooling
7E. Vitamin D addition
8E. Canning
9E. Preheating
10E. Sterilization
11E. Final cooling

Very little delay time occurs between each step in the manufacture of the evaporated milk since it is a continuous process. However, a delay of several hours occurs at step 7E since a constant supply is desirable for the remaining processes. An average total elapsed time in passing through the above process is estimated to be twenty-four hours.

Iodine–131 concentrations found in samples collected at the specified locations are given in table 1.

Comparison of the iodine–131 content in the raw milk with the iodine–131 content in the

---

[1] Mr. Raymond is Senior Sanitary Engineer, Bureau of Radiological Health Services, New York State Health Department, Albany, New York. Mr. Williams, Senior Assistant Sanitary Engineer, Public Health Service, was assigned to the Bureau of Radiological Health Services, during the period involving the study.

[2] Samples were analyzed by the New York State Department of Health, Division of Laboratories and Research.

TABLE 1.—EVAPORATED MILK PLANT SAMPLE RESULTS, SEPTEMBER 18, 1962

Location from which sample is secured	I^{131} (pc/liter) [a]
Mixed raw milk from storage tank taken prior to hot wells, step 2E	326
Evaporated homogenized milk prior to addition of Vitamin D, step 7E	811

[a] The statistical counting error was within 10 percent for a 95 percent confidence limit.

evaporated milk indicates that the activity more than doubled in concentration. This increase in iodine–131 concentration may be closely associated with the volumetric change occurring during the manufacture of the evaporated milk. This plant uses approximately 2.3 volumes of raw milk to produce one volume of evaporated milk. Hence, it is apparent that when evaporated milk is reconstituted a similiar dilution factor would reduce the iodine–131 concentration correspondingly.

Powdered Skim Milk Process and Sampling Results

The manufacturing process for making powdered skim milk is summarized in the following four steps.

1P. Raw milk receipt and storage
2P. Milk separation (skim milk and cream)
3P. Skim milk concentration through evaporation
4P. Concentrate powdering (by spray dryer or roll dryer)

Concentrations of iodine–131 found in milk sampled from the above steps are shown in table 2 below.

Approximately one-fifth of a pound of powdered milk is mixed with water to produce each quart of skim milk. This corresponds to about 0.095 kg of powder per liter of milk. Therefore, the iodine–131 concentration in milk reconstituted from either spray or roll dried powder would be approximately 40 percent less than the iodine–131 concentration in raw milk.

TABLE 2.—POWDERED MILK PLANT SAMPLE RESULTS, OCTOBER 3, 1962

Location from which sample is secured	I^{131} (pc/liter) [a]	I^{131} (pc/ powder) [a]
Raw milk from storage tank, step 1P	176	
Skim milk after separator, step 2P	170	
Cream after separator, step 2P	128	
Concentrate after evaporators, step 3P		1,070
Powdered milk from spray dryer, step 4P		1,070
Powdered milk from roll dryer, step 4P		1,048

[a] The statistical counting error was within 10 percent for a 95 percent confidence limit.

Discussion

The results of this limited study indicate that no iodine–131 activity was lost in the processes of maunfacturing evaporated milk, but there was some loss of iodine–131 in the manufacturing of powdered milk. Hence, it would appear that any public health action involving the use of evaporated milk, in the event that high iodine–131 levels were experienced in raw milk, would be based solely on the additional delay time that the distribution and storing process would give to the milk product as it proceeds from producer to consumer. However, there appears to be some reduction of iodine–131 activity in reconstituted powdered skim milk due to the manufacturing process.

Limited information secured during the investigation indicates that it is possible for the delay time accounted for by both processing and storage in these processing plants to be very small—possibly on the order of a few days. Detailed information on this subject was not pursued in this study, nor was it readily available. Information obtained at the evaporated milk plant indicated that, based on the dictates of economy and product quality, sixty days would usually be the maximum time that the manufactured product would remain in their plant. For the above reasons, the early depletion of a stored supply of evaporated or powdered milk would also have to be considered if this type of countermeasure is to be effective.

The results obtained in this study were not conclusive; however, they do point out a problem area where additional studies are necessary to ascertain the iodine–131 content in relation to both the manufacturing and the marketing practices of evaporated and powdered milk.

REFERENCES

(*1*) National Advisory Committee on Radiation: *Radioactive Contamination of the Environment: Public Health Action*. Division of Radiological Health, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

(*2*) Dubrovina, Z. V. and O. M. Belova (Chelyabinsk), Passage of Strontium-90 From Milk to Various Dairy Products During Various Technological Production Processes, *Gigiyena I. Sanitaria 28*:105-8, U. S. S. R. (1963). Available as one of five articles translated

as a set from a volume of the Russian-language medical journal (Hygiene and Sanitation). Publication 100, JPRS: 18,49, *Translations From Gigiyena I. Sanitaria*, April 2, 1963, Office of Technical Services, U. S. Department of Commerce, Bldg. T-30, Washington D. C. 20230. Price $1.00.

(3) Demott, B. J., and D. E. Easterly: Removal of Iodine-131 From Milk, *Journal of Dairy Science, 43:* 1148-50 (August 1960).
(4) Pasternack, Bernard S.—Linear Estimation and the Analysis of Gamma Ray Pulse Height Spectra, *Technometrics; 4*:565-72, (1962).

STRONTIUM-90 AND CALCIUM IN UNITED STATES WHEAT (1962) AND MILLING PRODUCTS (1958-1962)[1]

Joseph Rivera [2]

Wheat

An important part of the fallout studies conducted at AEC's Health and Safety Laboratory for the last several years has been the measurement of strontium–90 contamination of wheat and milling products. Data have been reported on the strontium–90 and calcium content of wheat grown in most of the important wheat producing States from 1958 through 1961 (*1*). Results of the analyses of samples from 1958 through 1961 (*1*). Results of the analyses of samples from the 1962 crop are presented in table 1.

TABLE 1.—STRONTIUM-90 AND CALCIUM IN UNITED STATES WHEAT SAMPLED IN 1962

State	Number of samples	Production [a] (millions of bushels)	g Ca/kg Wheat	pc Sr^{90}/kg Wheat	pc Sr^{90}/g Ca
California	1	9.6	0.40	14	35
Colorado	2	36.2	0.43	85	197
Idaho	2	36.7	0.29	20	70
Iowa	1	2.2	0.47	138	294
Kansas	1	211.2	0.32	90	282
Missouri	1	26.4	0.44	128	292
Montana	1	78.3	0.29	64	221
Nebraska	3	53.8	0.44	161	367
New York	1	6.8	0.40	100	250
North Dakota	1	158.5	0.30	100	334
Oklahoma	1	72.0	0.33	101	306
Texas	1	43.7	0.50	51	101
Utah	1	5.4	0.44	23	52
Washington	1	66.8	0.36	14	40
Total	18	[b]807.6	—	—	—
Arithmetic—					
Average			0.39	78	203
Standard deviation			0.07	46	115
Production Weighted—					
Average			0.35	83	246
Standard deviation			0.06	37	103

[a] Production values obtained from *Wheat Facts 1* (*3*).
[b] This total is 74% of the amount of wheat produced in the United States.

It is apparent from the data presented that there has been an appreciable change in the concentrations of strontium–90 found in the 1962 crop as compared to those found in 1961. The production weighted average strontium–90 concentration for the 1962 crop was 83 ± 37 pc/kg as compared to 23 ± 10 pc/kg observed in 1961. The average Sr^{90}/Ca ratio was 246± 103 strontium units in 1962 as compared to 72 ± 36 strontium units found in 1961. The changes in the Sr^{90}/Ca ratios of wheat since 1958 may be seen in figure 1.

These investigations are being carried out primarily to add to the understanding of the mechanism of contamination of wheat by strontium–90. As was pointed out previously (*2*), the origin of the strontium in wheat is either the soil or direct deposition on the aerial parts of the plant. An empirical formula has been deduced to express the average contamina-

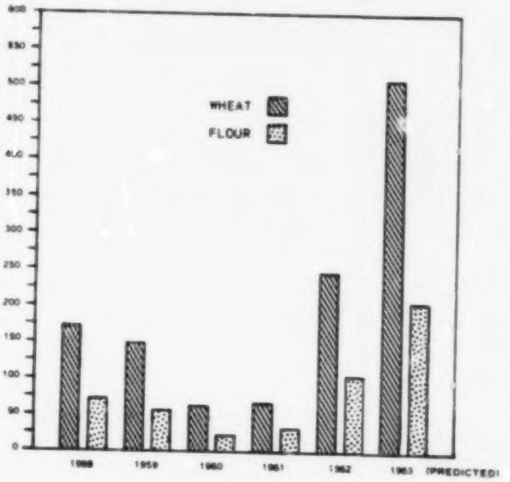


FIGURE 1.—STRONTIUM-90/CALCIUM RATIOS IN UNITED STATES WHEAT AND FLOUR

tion the U. S. wheat crop in terms of the average deposition of strontium–90 in June and the estimated cumulative deposit of strontium–90 in the midwest soils. The formula is:

---

[1] Data from *Fallout Program Quarterly Summary Report, HASL-140*:276-81. Office of Technical Services, Department of Commerce, Washington, D. C. 20430 (October 1, 1963), price $4.00.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York 14, N. Y.

$$V = aS + bR,$$

where V is the production weighted Sr^{90}/Ca ratio in wheat grown in the United States in a given year in pc Sr^{90}/g Ca, S is the strontium–90 content of soil on which the wheat was grown in mc Sr^{90}/mi^2 for the middle of the crop year, (June), R is the amount of fallout in mc Sr^{90}/mi^2 deposited in June of the crop year, and a and b are proportionality factors that must be determined.

Using the data on V, S and R obtained for the 1958, 1959, and 1960 crops, the best estimate of the parameters a and b were found by multiple regression analysis to be 0.1 and 100, respectively. These values were used in the equation to predict V for 1961. The predicted value was 69 pc Sr^{90}/g Ca, and the observed value was 63 pc Sr^{90}/g Ca. The predicted value for the 1962 crop was 331 pc Sr^{90}/g Ca while the observed value was 246 pc Sr^{90}/g Ca.

Since data were now available on V and S and R for two additional years, values of a and b could be recalculated. The input data—V, R, and S—for this calculation are tabulated in table 2.

The values of S and R listed in table 2 are slightly different from those given in HASL–132 (*1*). The estimates given here were made by averaging all of the results obtained from the HASL monthly pot and column fallout collection network in the United States while the values previously used were obtained by averaging only the data from the few midwest collection sites.

The new values of $a = 0.19$ and $b = 95$ were found by multiple regression analysis of the data for five years. The equation relating strontium–90 in the environment to that in wheat now becomes:

$$V = 0.19S + 95R$$

TABLE 2.—AVERAGE STRONTIUM-90 IN WHEAT, SOIL, AND FALLOUT IN THE UNITED STATES

Year	Vp Predicted Sr^{90}/Ca in wheat (pc/g)	Vo Observed Sr^{90}/Ca in wheat (pc/g)	S June Sr^{90} in soil (mc/mi^2)	R June Sr^{90} fallout deposition (mc/mi^2)
1958	133	172	46	1.30
1959	162	147	67	1.57
1960	56	62	73	0.44
1961	67	63	77	0.55
1962	259	246	92	2.55

The "goodness of fit" attained by the use of this equation may be judged by comparing observed (Vo) and the predicted (Vp) Sr^{90}/Ca ratios for the last five years as shown in table 2.

The agreement between observed and predicted levels of about ± 10 percent suggest that the model used is a reasonable one. The new value of the a factor of 0.19 is in excellent agreement with the value of 0.2 calculated from field experiments of Milbourne in the United Kingdom (*4*) and in fair agreement with the value of 0.1 found by Menzel for wheat grown in Maryland (*5*).

The model may now be used to estimate the strontium–90 content of the 1963 wheat crop. The cumulative level of strontium–90 in midwest soils in June 1963 is estimated to have been about 125 mc/mi^2. The fallout deposition of strontium–90 during June 1963 is estimated to have been about 5.25 mc/mi^2. Therefore, the estimated level of strontium–90 contamination of wheat grown in the United States in 1963 is 523 pc Sr^{90}/g Ca. This predicted value is plotted in figure 1 along with the levels observed in previous years.

Milling Products

In addition to measuring the strontium–90 content of wheat, milling products from many States have also been analyzed. Results of the analyses of samples from 1958, 1959, and 1960 crops were reported in HASL–122 (*6*). Since it was found that on the average the distribution of strontium–90 in the milling products was approximately constant from year to year, the nationwide sampling of milling products was discontinued and only milling products from the Kansas crop of 1961 and 1962 were analyzed. These results are given in table 3. These data have been extrapolated to include the entire United States and are presented in table 4 along with results from the previous years. The proportionality between the strontium–90 content of wheat and the flour milled from it may also be seen from the data in figure 1.

TABLE 3.—STRONTIUM-90 AND CALCIUM IN MILLING PRODUCTS FROM KANSAS WHEAT

Product	1961			1962		
	g Ca/kg wheat	pc Sr^{90}/kg wheat	pc Sr^{90}/g Ca	g Ca/kg wheat	pc Sr^{90}/kg wheat	pc Sr^{90}/g Ca
Wheat	0.38	34	89	0.32	90	282
Patent flour	0.20	6	32	0.21	17	82
Clear flour	—[a]	—	—	0.39	57	146
Germ	1.00	88	87	—	—	—
Shorts	0.24	8	36	1.04	370	356
Bran	—	—	—	1.26	486	386

[a] Dash indicates no sample.

TABLE 4.—PRODUCTION WEIGHTED AVERAGE STRONTIUM-90 CALCIUM RATIOS IN WHEAT AND FLOUR IN THE UNITED STATES

Year	pc Sr^{90}/g Ca		Ratio: (pc Sr^{90}/g Ca) flour (pc Sr^{90}/g Ca) wheat
	Wheat	Flour	
1958	172	72	0.42
1959	147	54	0.37
1960	62	24	0.39
1961	63	[a]32	0.51
1962	246	[a]82	0.33

[a] These values are for Kansas only.

From these data it would appear that a reasonable estimate of the Sr^{90}/Ca ratio of flour would be about 0.4 times the Sr^{90}/Ca ratio of wheat. Since the predicted Sr^{90}/Ca ratio of wheat grown in the United States, in 1963 is 523 pc Sr^{90}/Ca, the predicted level in flour is 209 pc Sr^{90}/g Ca.

If the moratorium on atmospheric testing of nuclear weapons continues, and the pattern of Sr^{90} deposition is as predicted in the Federal Radiation Council Report No. 4 (*7*), then the level of contamination of the United States wheat by strontium-90 should decline rapidly from its peak of 523 pc Sr^{90}/g Ca in 1963 to about 200 pc Sr^{90}/g Ca in 1964.

REFERENCES

(*1*) Rivera J: Strontium-90 and Calcium in the 1961 U. S. Wheat Crop, *Fallout* Program Quarterly Summary Report, HASL-132:224-7, abstracted in *Radiological Health Data, 4*:132-3 (March 1963).

(*2*) Rivera, J.: Strontium-90 Levels in U. S. Wheat and Milling Products through 1960, *Fallout Program Quarterly Summary Report, HASL-122*:188-92, Office of Technical Services, Department of Commerce, Washington, D. C. 20230 (April 1, 1962) Price $3.00.

(*3*) United States Department of Agriculture: *Wheat Facts* 1, Report No. PA-551, (January 1963).

(*4*) Milbourne, G. M., Ellis, F. B., and Russell, R. S.: *The Absorption of Radioactive Strontium by Plants Under Field Conditions in the United Kingdom*, Conference on the Passage of Fission Products through Food Chains, Harwell, September 23-25, 1958.

(*5*) Menzel, R. G., Myhre, D. S., and Roberts, H.: "Foliar Retention of Strontium-90 by Wheat," *Science 134*:559-60 (August 25, 1961).

(*6*) Rivera, J.: Strontium-90 Levels in U. S. Wheat and Milling Products Through 1960, Fallout Program Quarterly Summary Report, HASL-122:188-92, (April 1, 1962). Abstracted in *Radiological Health Data, 3*:392-5 (October 1962).

(*7*) Federal Radiation Council: Estimates and Evaluation of Fallout in the United States From Nuclear Weapons Testing Conducted Through 1962, Report No. 4, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (May 1963) Price 30 cents.

Previous coverage in *RHD:*

Period	Issue
1958	*May 1960*
1958-60	*October 1960*
1958-59	*November 1960*
1959	*April 1961*
1958-59	*July 1961*
1959-60	*January 1962*
1958-60	*October 1962*
1958-61	*March 1963*

STRONTIUM-90 IN CANADIAN WHEAT, 1962 [1]

H. Taniguchi [2]

A comprehensive program for the measurement of strontium–90 in Canadian wheat was started in 1959 by the Radiation Protection Division of the Canadian Department of National Health and Welfare, with the assistance of the Department of Trade and Commerce and Atomic Energy of Canada Limited. The actual sampling for the program was planned and carried out by the Grain Research Laboratory and the Grain Inspection Branch of the Board of Grain Commissioners for Canada.

The major wheat growing areas for hard red spring wheat were divided into nine districts as shown in figure 1.

At the end of a crop year, ten pounds of wheat were obtained from each district. Each sample was a composite of a large number of smaller samples obtained within a district, weighted according to production, and was closely representative of all the wheat produced in that district.

Method of Analysis

The method of analysis and results for a variety of samples of stored wheat from the 1957 and 1958 crop years and of wheat exported from the Pacific and Atlantic seaboard ports have been reported from the Low Level Laboratory of Atomic Energy of Canada, Limited, at Deep River, Ontario, by Grummitt and Robertson (*1*).

The method was adapted from the procedure used for strontium–90 determinations in milk (*2, 3*). In most cases, 500 grams of each composite were taken. These samples, as received, were thoroughly heated at 200° C and dry-ashed at 600° to a white residue. The resulting ash was leached with 6 *N* hydrochloric acid in the presence of strontium carrier. The strontium fraction was isolated by elution with 6 *N* hydrochloric acid from a cation exchange column after the calcium had been removed by eluting with ammonium lactate. Yttrium–90 growing in from this further purified strontium fraction was then separated and counted. The chemical recovery of strontium carrier was corrected for the natural strontium content of the sample, assuming an average correction of 3 percent (*1*). A portion of the hydrochloric acid leach was analyzed for calcium by double precipitation of the oxalate and titration of the oxalate with potassium permanganate in the presence of sulfuric acid.

TABLE 1.—STRONTIUM-90 IN CANADIAN HARD RED SPRING WHEAT IN CROP YEAR 1962

District	Production in millions of bushels	g Ca/kg wheat	pc Sr^{90}/kg wheat	pc Sr^{90}/g Ca
1	45.1	0.238	93	391
2	26.0	0.300	98	327
3	102.1	0.244	56	230
4	72.2	0.291	53	182
5	35.8	0.322	74	230
6	65.4	0.318	82	258
7	20.9	0.346	50	144
8	63.8	0.284	106	373
9	11.3	0.262	87	332
Total	442.4	—	—	—
Arithmetic				
Average		0.289	78	274
Standard deviation		0.051	20	81
Production weighted				
Average		0.283	75	267
Standard deviation		0.041	38	76

Results and Discussion

The results of the analyses of whole wheat for the crop year 1962 are presented in table 1.

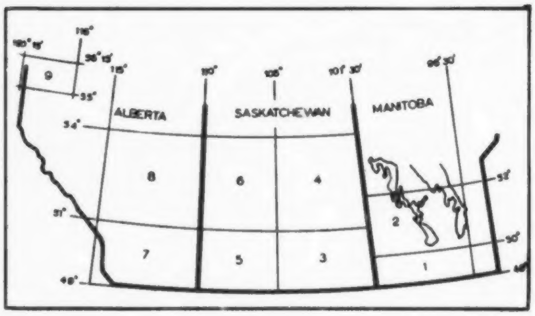


FIGURE 1.—WHEAT SAMPLING DISTRICTS OF CANADA

---

[1] Data from *Radiation Protection Programs*, Vol. 1, No. 9:19, Radiation Protection Division, Canadian Department of National Health and Welfare, (September 1963).

[2] Mr. Taniguchi is a radiochemist with the Radiation Protection Division of the Canadian Department of National Health and Welfare, 370 Sparks Street, Ottawa 4, Ontario, Canada.

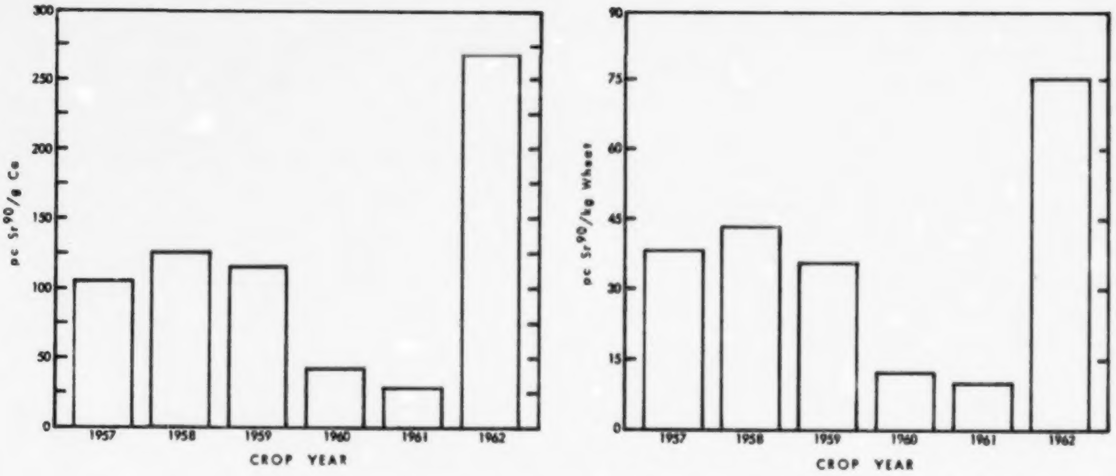


FIGURE 2.—PRODUCTION WEIGHTED AVERAGE STRONTIUM-90 IN CANADIAN WHEAT

Strontium-90 values in wheat for the years 1957 through 1962 are presented graphically in figure 2. The estimated production figures, supplied by the Grain Research Laboratory, were used to calculate the reported weighted averages. Where there was a significant delay between sampling and analysis, the values were corrected for decay of strontium-90 to September of the year in which the wheat was grown.

As shown in figure 2, the production weighted average strontium-90 concentration in wheat in 1962 was eight times that in 1961. Although this value of 75 pc Sr^{90}/kg wheat for 1962 is the highest value observed since the beginning of the program in 1957, it is only 1.7 times the previous maximum which occured in 1958. Because the concentration of calcium in wheat is relatively constant, the amount of strontium-90 per gram of calcium also follows the same pattern as the strontium-90 concentrations in wheat.

The arithmetic statistics presented in table 1 show the average and variation of any wheat contamination by strontium-90 regardless of the amount produced. The production weighted statistics show the average and variation which may be expected in the contamination of the total quantity of wheat produced.

It must emphasized that the reported values are for whole wheat, not wheat flour. This is significant because much of the strontium-90 is in the bran fraction. For example, Grummitt and Robertson (*1*) found that the amount of strontium-90 in white flour milled from wheat harvested in 1957 and 1958 was less than that in whole wheat by a factor of 8 on a weight basis (a factor of 3.3 relative to calcium). The corresponding ratios between bran and flour from wheat harvested in other years are not available.

Acknowledgements

The collection and composition of the samples were arranged by Dr. J. A. Anderson, of the Grain Research Laboratory, Winnipeg. The advice and assistance received from Dr. W. E. Grummitt and G. Lahaie, of Atomic Energy of Canada Limited, in the radiochemical analyses are grateful acknowledged. The analyses in the Radiation Protection Division Laboratory were carried out by G. E. Holmes and J. M. Quinn.

REFERENCES

(*1*) Grummitt, W. E., and E. R. Robertson: *Strontium-90 and Cesium-137 in Canadian Wheat, 1957-1959, Atomic Energy of Canada Limited Report CRER-1000* (1960).

(*2*) Grummitt, W. E., and Gwen M. Milton: *Radiochemical Procedures for Strontium and Yttrium, Atomic Energy Of Canada Limited Report CRC-688* (1957).

(*3*) Mar, P. G.: *Outline of Procedure for the Radiochemical Analysis of Dried Milk Powder for Strontium and Yttrium, Department of National Health and Welfare Report, RPD-5* (1960).

Section III—Water

RADIOACTIVITY IN RAW SURFACE WATERS—NATIONAL WATER QUALITY NETWORK, AUGUST 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 128 stations as of January 1, 1964, operated jointly with Federal, State and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*)

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once monthly except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Network laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample

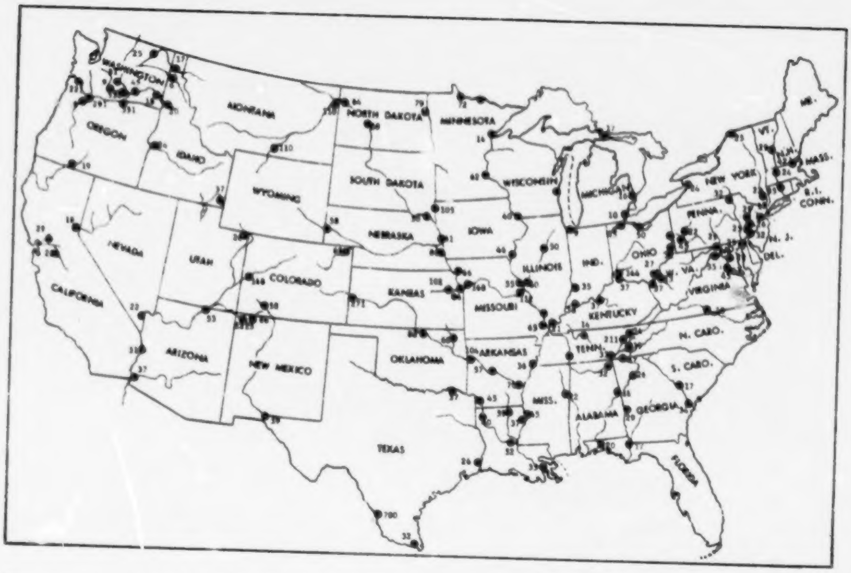

WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
WISCONSIN
MICHIGAN
NEW YORK
ME.
VT.
MASS.
R.I.
CONN.
PENNA.
N. J.
DEL.
NEVADA
UTAH
COLORADO
NEBRASKA
IOWA
ILLINOIS
IND.
OHIO
W. VA.
VIRGINIA
CALIFORNIA
KANSAS
MISSOURI
KENTUCKY
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, AUGUST 1963

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa.	1	21	22	0	0	0
Animas River:						
Cedar Hill, N. Mex.	49	17	66	8	2	10
Apalachicola River:						
Chattahoochee, Fla.	4	13	17	0	0	0
Arkansas River:						
Coolidge, Kansas	194	77	271	22	29	51
Ponca City, Okla.	7	81	88	0	9	9
Fort Smith, Ark.	31	73	104	3	3	6
Little Rock, Ark.	24	33	57	2	2	4
Pendleton Ferry, Ark.	23	47	70	1	0	1
Bear River:						
Preston, Idaho	4	33	37	0	2	2
Big Horn River:						
Hardin, Mont.	72	38	110	2	7	9
Big Sioux River:						
Sioux Falls, S. Dak.	30	75	105	3	0	3
Chattahoochie River:						
Atlanta, Ga.	18	8	26	1	0	1
Columbus, Ga.	8	21	29	0	0	0
Lanett, Ala.	7	9	16	1	0	1
Chena Slough:						
Fairbanks, Alaska	6	14	20	0	0	0
Clearwater River:						
Lewiston, Idaho	3	17	20	0	1	1
Clinch River:						
Clinton, Tenn.	4	10	14	0	0	0
Kingston, Tenn.	29	182	211	<1	1	1
Colorado River:						
Loma, Colo.	95	53	148	12	14	26
Page, Ariz.	11	42	53	2	8	10
Boulder City, Nev.	2	20	22	0	11	11
Parker Dam, Calif-Ariz.	0	31	31	0	7	7
Yuma, Ariz.	0	37	37	0	18	18
Columbia River:						
Northport, Wash.	4	21	25	0	0	0
Wenatchee, Wash.	16	15	31	0	0	0
Pasco, Wash.	54	476	530	<1	0	<1
McNary Dam, Ore.	36	315	351	0	0	0
Bonneville, Ore.	30	261	291	0	<1	<1
Clatskanie, Ore.	18	023	221	0	<1	<1
Cumberland River:						
Clarksville, Tenn.	3	11	14	0	0	0
Connecticut River:						
Wilder, Vt.	11	18	29	0	1	1
Northfield, Mass.	4	20	24	0	0	0
Enfield Dam, Conn.	9	26	35	1	0	1
Cuyahoga River:						
Cleveland, Ohio	10	40	50	1	1	2
Delaware River:						
Martins Creek, Pa.	6	23	29	0	0	0
Trenton, N.J.	10	16	26	0	0	0
Philadelphia, Pa.	5	20	25	1	0	1
Escambia River:						
Century, Fla.	11	9	20	1	0	1
Great Lakes:						
Duluth, Minn.	2	12	14	0	0	0
Sault Ste. Marie, Mich.	5	12	17	0	0	0
Gary, Ind.	0	9	9	0	0	0
Port Huron, Mich.	4	12	16	0	0	0
Detroit, Mich.	2	8	10	0	0	0
Buffalo, N.Y.	4	20	24	0	1	1
Green River:						
Dutch John, Utah	0	26	26	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	1	21	22	0	1	1
Illinois River:						
Peoria, Ill.	5	45	50	0	2	2
Grafton, Ill.	21	34	55	1	1	2
Kanawha River:						
Winfield Dam, W. Va.	0	13	13	0	1	1
Klamath River:						
Keno, Ore.	4	15	19	0	0	0
Kansas River:						
De Soto, Kans.	45	57	102	3	1	4
Maumee River:						
Toledo, Ohio	8	37	45	2	1	3
Little Miami River:						
Cincinnati, Ohio	77	67	144	1	0	1
Merrimack River:						
Lowell, Mass.	16	26	42	0	1	1
Mississippi River:						
St. Paul, Minn.	7	55	62	0	1	1
Dubuque, Iowa	0	40	40	0	2	2
Burlington, Iowa	8	38	46	0	1	1
E. St. Louis, Ill.	21	39	60	1	1	2
Cape Girardeau, Mo.	29	36	65	3	1	4
W. Memphis, Ark.	3	33	36	1	2	3
Vicksburg, Miss.	17	28	45	1	1	2
Delta, La.	17	20	37	3	1	4
New Orleans, La.	2	33	35	0	3	3

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, AUGUST 1963—Continued

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Missouri River:						
Williston, N. Dak.	16	48	64	2	2	4
Bismarck, N. Dak.	17	41	58	0	4	4
Yankton, S. Dak.	9	41	50	0	3	3
Omaha, Nebr.	22	39	61	0	6	6
St. Joseph, Mo.	35	31	66	4	2	6
Kansas City, Kans.	51	33	84	7	2	9
Missouri City, Mo.	129	39	168	10	7	17
St. Louis, Mo.	83	29	112	9	3	12
Monongahela River:						
Pittsburgh, Pa.	1	44	45	0	0	0
North Platte River:						
Henry, Nebr.	16	42	58	1	13	14
Ohio River:						
Addison, Ohio	2	25	27	0	0	0
Huntington, W. Va.	4	33	37	0	0	0
Cincinnati, Ohio	3	34	37	0	0	0
Louisville, Ky.	4	33	37	0	0	0
Evansville, Ind.	4	34	38	0	0	0
Cairo, Ill.	1	20	21	<1	<1	1
Toronto, Ohio	4	28	32	<1	<1	1
Ouachita River:						
Bastrop, La.	13	46	59	1	1	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	4	13	17	0	0	0
Platte River:						
Plattsmouth, Nebr.	43	43	86	2	2	4
Potomac River:						
Williamsport, Md.	2	27	29	0	0	0
Great Falls, Md.	7	22	29	0	1	1
Washington, D. C.	14	31	45	0	0	0
Rainy River:						
Baudette, Minn.	16	56	72	0	0	0
Raritan River:						
Perth Amboy, N. J. (5-ft. Below Surface)	0	12	12	0	4	4
Perth Amboy, N. J. (5-ft. Above Bottom)	0	10	10	0	3	3
Red River, North:						
Grand Forks, N. Dak.	9	70	79	1	1	2
Red River, South:						
Denison, Tex.	4	33	37	0	1	1
Index, Ark.	2	43	45	0	2	2
Bossier City, La.	8	32	40	1	2	3
Alexandria, La.	9	43	52	1	4	5
Rio Grande River:						
Alamosa, Colo.	27	31	58	1	2	3
El Paso, Tex.	44	15	59	9	5	14
Laredo, Tex.	663	37	700	3	2	5
Brownsville, Tex.	3	29	32	0	0	0
Roanoke River: John H. Kerr Resr/Dam, Va.	4	14	18	1	0	1
Sabine River:						
Ruliff, Tex.	6	20	26	0	0	0
Sacramento River:						
Courtland, Calif.	22	7	29	2	0	2
San Joaquin River:						
Vernalis, Calif.	5	23	28	0	9	9
San Juan River:						
Shiprock, N. Mex.	2184	31	2215	446	8	454
St. Lawrence River:						
Massena, N. Y.	6	19	25	0	0	0
Schuylkill River:						
Philadelphia, Pa.	6	26	32	0	0	0
Savannah River:						
North Augusta, S. C.	3	14	17	0	0	0
Port Wentworth, Ga.	13	21	34	0	0	0
Shenandoah River:						
Berryville, Va.	24	31	55	1	1	2
Ship Creek:						
Anchorage, Alaska	4	7	11	0	0	0
Snake River:						
Ice Harbor Dam, Wash.	0	18	18	0	1	1
Wawawai, Wash.	24	21	45	1	2	3
Payette, Idaho	8	16	24	0	4	4
South Platte River:						
Julesburg, Colo.	7	62	69	1	27	28
Spokane River:						
Post Falls, Idaho	0	6	6	0	0	0
Susquehanna River:						
Sayre, Pa.	7	25	32	0	0	0
Conowingo, Md.	1	24	25	1	0	1
Tennessee River						
Lenoir City, Tenn.	2	17	19	1	0	1
Chattanooga, Tenn.	5	32	47	0	0	0
Bridgeport, Ala.	2	30	32	0	0	0
Pickwick Landing, Tenn.	9	24	33	0	0	0
Tombigbee River:						
Columbus, Miss.	6	16	22	0	0	0
Truckee River:						
Farad, Calif.	5	13	18	0	0	0
Verdigris River:						
Nowata, Okla.	9	51	60	0	1	1
Wabash River:						
New Harmony, Ind.	4	31	35	0	1	1
Willamette River:						
Portland, Ore.	3	5	8	0	0	0
Yakima River:						
Richland, Wash.	2	7	9	0	2	2
Yellowstone River:						
Sidney, Mont.	71	39	110	1	3	4
Maximum	2184	476	2215	446	29	454
Minimum	0	5	6	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (*6*).

when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (7). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning November 1962, strontium-90 analyses were reduced to a semi-annual basis at each sampling point except at those stations immediately below nuclear installations. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the aforementioned reference (*7*). Tributyl phosphate was used to extract ingrown yttrium–90 from the purified, coprecipitated strontium–90. Since that time, a modification of a procedure described by Harley has been used (*8*). The yttrium–90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents August 1963 results of alpha and beta analyses of U. S. raw surface waters. These data are preliminary; reanalysis of some samples and some analyses which are not completed at the time of this report will be included in the Network's Annual Compilation of Data (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made. The most recent quarterly strontium–90 results appeared in the January 1964 *Radiological Health Data (9)*.

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the August 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957-1962 have been summarized by Weaver *et al* (*10*).

Discussion

Analysis of the preliminary August 1963 data indicates several apparently abnormal levels of alpha and beta activity (pc/liter) in the suspended solids fractions of the reported results. The monthly average suspended alpha and beta activities values for the San Juan River at Shiprock, New Mexico, were reported to be 446 and 2,184 pc/liter, respectively. The dissolved alpha and beta activities were not significantly different from those commonly observed at this sampling point. Suspended beta activity averaged 663 pc/liter on samples from the Rio Grande at Laredo, Texas. Samples from other stations on this river indicated no unusual values. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations in order to avoid excessive self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting error associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to the specific activity observed normally in samples from these stations. The apparent increased activity, therefore, may be considered attributable to the extremely high suspended solids content of the samples and essentially of natural origin.

On the Columbia and Clinch Rivers the monthly dissolved beta activity averages were greater than 100 pc/liter. Of these observed averages, four ranged between 203 and 476 pc/liter and occurred downstream from the Hanford Atomic Products Operation facility. An average of 182 pc/liter of dissolved beta activity was recorded at the mouth of the Clinch River at Kingston, Tennessee, below the Oak Ridge area. While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough measure of the levels which may be found in treated water since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentrations do not exceed 1000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663*, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

---

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90 respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

32

(5) *Ibid.*, 1962 Edition (in press).

(6) *Ibid.*, 1963 Edition (to be published).

(7) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York, (1960).

(8) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(9) Public Health Service: National Water Quality Network, July 1963, *Radiological Health Data* 5:31-35, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402. (January 1964).

(10) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data* 4:306-16, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402. (June 1963).

(11) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association* 53:704 (June 1961).

(12) Public Health Service: Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402. (March 1963), price 30 cents.

Section IV—Other Data

CESIUM-137 AND POTASSIUM IN FINNISH LAPPS AND THEIR DIET [1]

J. K. Miettinen, A. Jokelainen, P. Roine, K. Lidén, and Y. Naversten [2]

Since 1958, investigations of the strontium–90 and cesium-137 contents of vegetation, animals and milk in Finland have been carried out (*1–6*). The results showed that concentrations of these radionuclides were quite high, especially in lichens, which grow extremely slowly, and in reindeer, whose principal feed is lichens during the main part of the year. A relatively high Cs^{137} content was observed also in cow's milk in Lapland.

As an introduction to further studies on people, a dietary investigation of the Finnish Lapps was carried out in the winter and summer of 1960 (*7*).

Food investigations in Norway had by this time indicated the possibility of high Cs^{137} body burdens in large groups of people in Scandinavia. This was verified by a study of 20 Norwegians in the whole-body counter at Lund in January 1961 (*8*) and of 3 Swedish Lapps measured in the spring of 1961. In the latter case the body burdens of Cs^{137} were found to be 30 to 40 times higher than in people living in southern Sweden (*9*). Thus it became evident that a unique contamination of humans existed in some regions of Scandinavia, particularly in areas near and north of the Arctic Circle.

A semi-portable whole body counter developed at Lund (*10*) was used in the determination of the Cs^{137} body burden in a large group of Swedish Lapps and other inhabitants in the Jokkmokk area (66.6°N, 19.9°E) in September 1961, before any fresh fallout had reached Sweden after the beginning of the second period of nuclear tests (*11*). In order to obtain directly comparable results in Finland and Sweden a similar study was carried out with the same equipment in the main living area of the Finnish Lapps, Inari (68.5°N, 26.5°E), in October 1961. At the same time an individual dietary interview was made on all the persons measured, which in combination with Cs^{137} determinations of representative dietary items, made it possible to calculate the average Cs^{137} content of the diet. This paper contains the condensed results of this Finnish-Swedish joint study.[3]

---

[1] Summarized from *Cesium-137 and Potassium in People and Diet—A Study of Finnish Lapps*, published in *Annales Academiae Scientiarum Fennicae*, Series A, II Chemica, No. 120, pp. 1–46 (1963).

[2] Dr. Miettinen is acting Head, Department of Radiochemistry, University of Helsinki, Finland; Miss Jokelainen is research assistant, Department of Nutritional Chemistry, University of Helsinki, Finland; Dr. Roine is Professor and Head, Department of Nutritional Chemistry, University of Hesinki, Finland; Dr. Lidén is Associate Professor and Head, Radiation Physics Department, University of Lund, Sweden; and Mr. Naversten is Research Assistant, Radiation Physics Department, University of Lund, Sweden.

[3] Preliminary reports of these results were given at the Second Northern Meeting on Radioactive Food Chains, held in Helsinki, April 2 to 3, 1962 (*12*) and at the Second Symposium on Radioactivity in Man, held in Chicago, September 5 to 7, 1962 (*13*).

SUBJECTS

The study was carried out in the county of Inari, the main living area of Finnish Lapps (7). Lapps of three different groups and non-Lapps were studied. The county was divided into 9 different areas as shown in figure 1 and a cluster sampling method was used for the choice of the Lapps. The non-Lapps were also from different parts of the county.

Classification of the persons investigated was made on the basis of (a) the traditional tribal groupings of the Finnish Lapps (7), (b) occupation, and (c) diet. It was possible to make a classification in which these three factors were not controversial.

The group of settled mountain Lapps, also called reindeer Lapps because they are reindeer breeders, is the largest in this study, comprising 116 people, 83 of whom are adults (50 men, 33 women) and 33 are boarding-school pupils (see below).

Only a few subjects were obtained in the fisher groups: ordinary fisher Lapps, 5 adult women; and reindeer breeding fisher Lapps, 6 adult men.

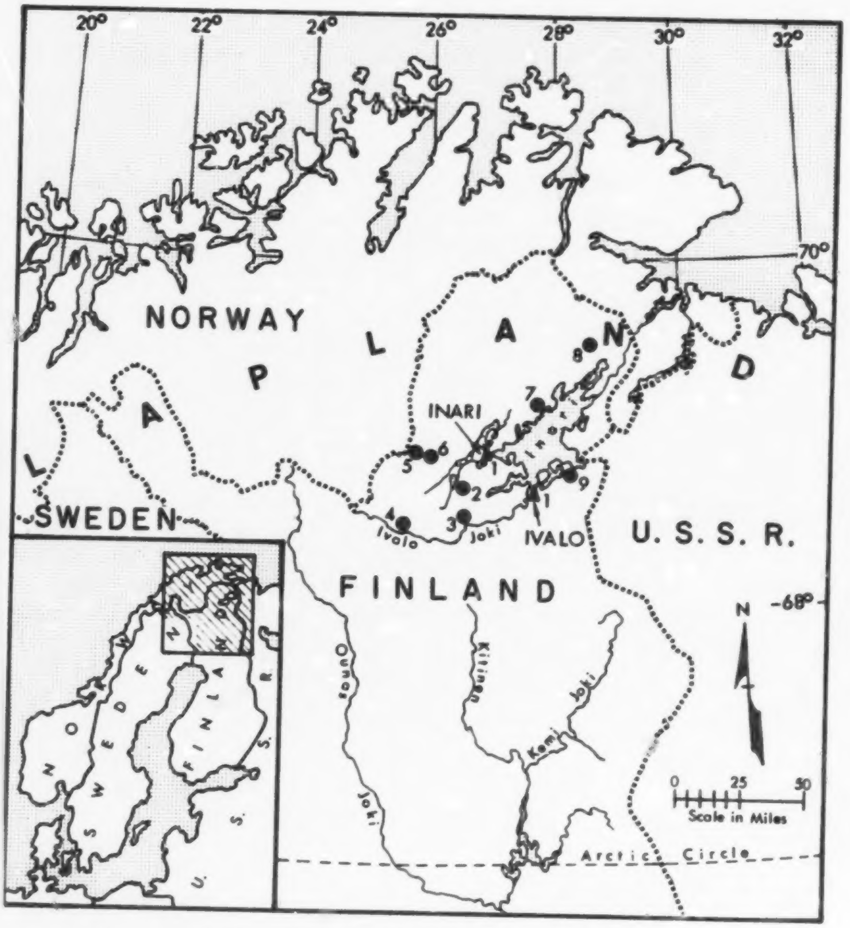

20°
22°
24°
26°
28°
30°
32°
70°
68°
NORWAY
L A P L A N D
SWEDEN
FINLAND
U. S. S. R.
INARI
IVALO
Ivalo Joki
Inari
1
2
3
4
5
6
7
8
9
N
0
25
50
Scale in Miles
Arctic Circle
Ounas Joki
Kitinen
Kemi Joki
NORWAY
SWEDEN
FINLAND
U.S.S.R.

FIGURE 1.—MAIN LIVING AREAS OF LAPPS IN INARI COUNTY

1. Inari and Ivalo villages
2. Menesjärvi
3. Kuttura
4. Lisma
5. Angeli
6. Vaskojoki
7. Partakko
8. Sevettijärvi
9. Nellimö

Those Lapps (thirteen in number) whose occupation prevented a correct classification in any of the above occupational groups, form the group of "Lapps of other occupations." These people represent a great variety of occupations, such as priest, teacher, nurse, taxi driver, carpenter, and janitor.

The fifth Lapp group consists of 42 boarding-school pupils.

The group of local non-Lapps (16 adult men and 15 adult women) represents a variety of occupations, both manual and nonmanual.

For comparison, 11 Helsinki inhabitants with apparently normal dietary habits were studied in December 1961.

FOOD CONSUMPTION

Method

The interview method was employed in the dietary survey. Particular attention was paid to the use of those foodstuffs which previous investigations (*7, 11*) had indicated to be the main sources of cesium-137 in the food consumed by the Lapps.

In order to facilitate the estimation of the amounts of different foodstuffs consumed, weighed samples were displayed. The subjects were asked to point out the kinds of bread, meat, and other foods they usually ate and to estimate their daily consumption with the aid of the samples.

Great differences occur in the consumption of certain foodstuffs in the course of longer periods of time; therefore the use of various foodstuffs was recorded for different periods of time, particular attention being paid to the use of reindeer meat.

The mean daily and monthly consumption of the different foodstuffs was calculated on the basis of the data obtained.

Results

Table 1 gives the mean consumption throughout the year of main foodstuffs per person per month in different population groups in Inari, and in the Helsinki group.

Of the cereals used, rye and wheat are the most important, and oats and rice are also used to some extent. All the cereals are brought to Lapland from elsewhere. Potatoes are grown on local farms. Of the meat consumed, the main part is reindeer meat from local herds; in addition commercial beef or pork sausages are used. Fish is obtained from local lakes and rivers. The bulk of the fish consumed is whitefish (*Coregonus* sp.), with pike (*Esox lucius* L.) being probably the second in importance. The Lapps obtain milk from their own cattle, and it is mainly used as such.

In Finland reindeer milk is no longer consumed to such an extent that it would have any significance as a component of the diet.

TABLE 1.—CONSUMPTION OF FOODSTUFFS

[Mean consumption per person in kg/month]

	Cereals	Potatoes and other root vegetables	Sugar	Margarine	Butter	Cheese	Milk	Cream	Meat [1]	Sausages	Fish
Males											
1. Lapps											
Reindeer breeders	7.8	11.9	1.70	1.53	0.89	0.29	19.4	1.78	12.4	4.85	9.1
Reindeer breeding fishers	7.9	13.2	1.10	2.00	0.13	1.00	10.0	1.12	11.9	0.87	10.1
Lapps of other occupations	9.4	12.4	2.44	0.64	1.46	0.54	24.2	1.77	5.7	1.32	5.5
Boarding-school pupils:											
16-19 yr.	7.8	7.7	1.44	1.09	0.38	0.06	2.5	0.45	3.4	0.26	6.0
10-14 yr.	6.0	11.1	0.89	1.12	0.55	0.34	26.7	0.91	2.7	0.18	3.1
2. Local Non-Lapps	9.6	12.1	1.36	0.66	1.86	0.30	32.9	1.05	5.5	0.74	5.4
3. Control group of Helsinki inhabitants	5.7	6.0[2]	0.75	—	1.38	0.70	43.3	2.40	2.9	0.84	0.9
4. Rural men in south Finland	10.8	12.1[3]	2.56	0.23	2.30	0.56	33.3	1.48	2.9	0.86	1.3
Females											
1. Lapps											
Reindeer breeders	5.3	9.3	1.15	1.03	0.30	0.13	12.9	1.22	4.3	0.08	7.2
Fishers	6.2	7.2	0.62	1.20	0.36	0.27	11.6	1.03	1.6	0.33	6.7
Lapps of other occupations	6.9	8.4	1.13	0.93	0.48	0.68	16.1	0.55	2.1	0.80	2.6
Boarding-school pupils:											
16-19 yr.	7.3	6.8	0.90	1.36	0.09	0.04	10.1	0.26	1.9	0.14	4.4
10-14 yr.	7.1	9.2	0.70	0.65	0.59	0.29	14.9	0.53	2.1	0.35	2.5
2. Local non-Lapps	4.9	5.7	0.71	0.33	0.83	0.63	17.1	0.57	1.8	0.86	2.7
3. Control group of Helsinki inhabitants	4.6	4.8[4]	0.74	0.24	1.24	0.70	30.3	0.50	1.6	0.40	0.1

[1] Carcass with bones.

[2] In addition fruits and berries 4.7 kg/month

[3] " " " " " 0.8 " and green vegetables 1.86 kg/month

[4] " " " " " 3.6 "

Margarine imported from Norway is the main food fat and it is used extensively. Of minor foodstuffs not included in table 1, berries might be of some significance, even though the consumption is very low (7). Lapps eat very little fruit; the consumption of fruit is also low in southern Finland.

The Lapps still depend to some extent on the natural economy. This affects their food consumption in the form of seasonal variations, which are particularly pronounced in the consumption of milk, fish and meat. Since the milk is exclusively obtained from local cattle, its use is largest in summertime, when production is most abundant. Also, fish is mainly eaten in summer. In some groups, 3 to 4 times as much fish is consumed in the summer as in winter when fishing is difficult owing to the freezing of lakes and rivers.

During the winter months (i.e. from November to April) the consumption of reindeer meat is highest in all groups (table 2). In May it drops radically and very little meat is eaten in the summer. In August the consumption is at its minimum, after which it gradually increases. The low consumption of meat in summer is partly due to poor preservation facilities, and for this reason the meat used in the summer is either strongly salted or dried. The restricted meat consumption in the summertime is understandable, as a great amount of fish is available at that time.

The largest seasonal variations in the consumption of reindeer meat are found among men of the reindeer breeder and reindeer-breeding fisher groups. During the periods when the Lapps are tending reindeer, bread and meat are their main foods. The mean reindeer meat consumption for men then exceeds 20 kg/month. The meat consumption for women in these groups is only one third of that for men. It should be noted that Lapps belonging to other occupational groups eat much less reindeer meat than the reindeer breeders. For the other occupation groups the meat consumption for Lapps is about the same as for non-Lapps.

CESIUM–137 AND POTASSIUM IN THE DIET

Collection of Samples

In connection with the dietary survey, samples of the most important constituents of the diet were collected. Special efforts were made to get samples as representative as possible of the locally produced foodstuffs. Fresh samples were sent to Helsinki by air mail, and were then weighed, dried at 105°C for 1 to 3 days, ground to a homogeneous powder, and measured by gamma spectrometry as will be described below.

Method of Cesium–137 and Potassium Determination in Food Samples

The radioactivity investigations were carried out at Lund. A lead cave supplied with a 3" x 2" NaI (Tl) crystal connected to a 200-channel transistorized pulse amplitude analyzer was used. A disposable plastic container in a fixed

TABLE 2.—CONSUMPTION OF REINDEER MEAT AT DIFFERENT TIMES OF THE YEAR

[Mean consumption per person in kg/month]

	November to April	May to July	August	September	October	All year 'round
Males						
1. Lapps						
Reindeer breeders	21.5	3.1	1.4	3.1	5.6	12.4
Reindeer breeding fishers	23.0	1.3	0.4	0.2	0.9	12.0
Lapps of other occupations	7.9	4.0	1.3	1.5	2.2	5.4
Boarding-school pupils						
16–19 yr.	6.0	0.8	0	0.9	1.0	3.4
10–14 yr.	3.9	2.0	0.8	0.4	0.4	2.7
2. Local Non-Lapps	9.0	0.9	0.2	1.0	3.5	5.1
Females						
1. Lapps						
Reindeer breeders	6.9	1.7	0.5	1.3	3.2	4.3
Fishers	3.0	0.2	0	0	0.2	1.6
Lapps of other occupations	3.2	0.8	0.1	0.2	0.5	1.9
Boarding-school pupils						
16–19 yr.	3.6	1.1	0.2	0.5	0.6	1.9
10–14 yr.	3.4	1.2	0.3	0.3	0.9	2.1
2. Local non-Lapps	1.8	0.5	0.5	0.5	0.8	1.2

position above the crystal was used for all samples. The container could take up to 1,500 cm^3 of any liquid or powdered sample. The volume and density were accurately determined for each sample.

Usually the samples were counted for one to four hours with automatic subtraction of a stored background. In the net spectra thus obtained we did not find any statistically significant amount of gamma emitters other than K^{40}, Cs^{137} and Cs^{134} in the energy region studied, 0.2 to 1.8 MeV (see figure 2).

Cesium-134 appeared in reindeer meat and pike, amounting in reindeer meat to 1.0 to 1.5 per cent of the Cs^{137} activity (*14*).

When all corrections are applied the estimated accuracy is ± 3 per cent in the determination of Cs^{137} and ± 5 percent for the K^{40} content. This does not include an inaccuracy due to counting statistics.

Results of Sample Measurements on Cesium–137

Table 3 gives the results of the sample measurements. The ratio Cs^{137}/K has been given in order to make possible a direct comparison with results which have been published by other authors on this basis only.

Reindeer Meat

The activity in reindeer meat during the winter of 1961 (18.0 nc/kg) is considerably lower than in 1960, when the shoulder of reindeer in Inari contained 35.3 nc/kg (*5*). In Norway a similar decrease has been observed

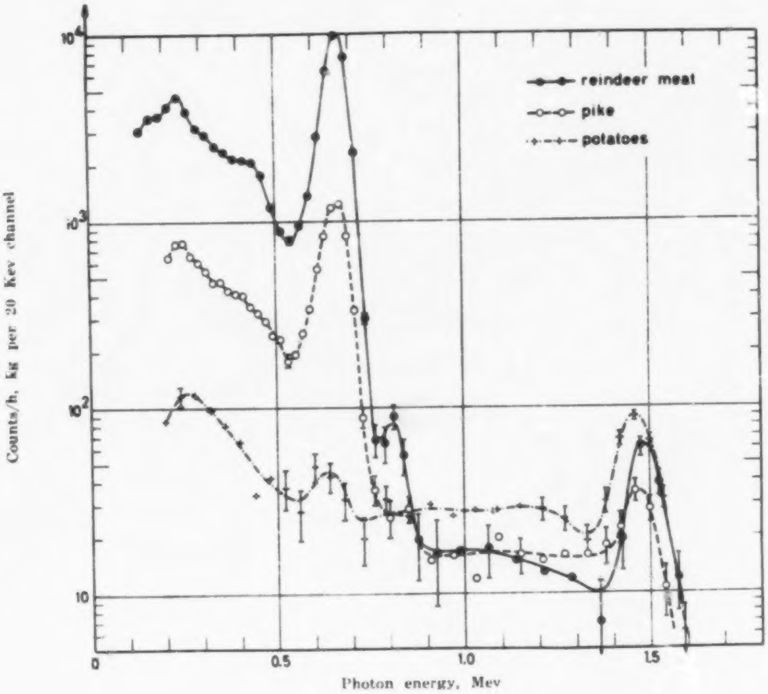


FIGURE 2.—NET γ-SPECTRA OF REINDEER MEAT, PIKE, AND POTATO

(The meat spectrum is run at 25 Kev/channel and the other spectra at 20 Kev/channel. In the potato spectrum each point represents an average of 2 or 3 channels. This is also valid for the other two spectra above 0.8 Mev. All counting rates are referred to 20 Kev/channel and normalized to one kg fresh weight.)

(*15*). The samples collected in autumn were less radioactive than the winter samples, as could be expected theoretically.

Fish

Pike contained 2.8 nc/kg fresh weight whereas the whitefish analyzed only contained 0.6 nc/kg. However, the high value of pike is probably not a peculiarity of Lapland, as similar values have been obtained from pike caught in southern Sweden (*16*). The difference is evidently due to different food chains, as pike is a predatory fish while the whitefish is a bottom feeder.

Milk

The average Cs^{137} content of cow's milk in Inari, 300 pc/liter, is at least 20 times higher than that in southern and central Finland. A survey made in 1959 gave an average for southern and central Finland of about 20 pc/liter (*4*). No survey was made in 1961, but Swedish measurements (*17*) show that the Cs^{137} content of milk decreased in 1961 to about half of the 1959 level; this is evidently true also for Finland.

On larger farms, especially in the valley of the Ivalo river, cultivated hay is the main fodder and the Cs^{137} content of the milk is relatively low; but on the more remote, smaller farms, where the cattle graze freely in the forest on wild hay, horsetail (*Equisetum fluviatile*), reindeer lichen, and other feed, the Cs^{137} content is in some cases quite high, even

TABLE 3.—CESIUM-137 AND POTASSIUM CONTENTS OF SAMPLES OF FOODSTUFFS COLLECTED IN INARI IN OCTOBER—DECEMBER 1961

Sample No.	Month of collection (1961)	Kind of food	Specific activity				nc Cs^{137} per g K
			Fresh weight		Standard dry weight		
			nc Cs^{137} per kg	g K per kg	nc Cs^{137} per kg	g K per kg	
		Locally produced:					
43	9	Reindeer meat	7.40 ±0.07[a]	2.7 ±0.3	31.1 ±0.3	11.2 ±1	2.67
84	10	"	15.50 ±0.04	3.1 ±0.1	58.0 ±0.3	11.7 ±0.3	4.98
86	10	"	16.00 ±0.05	2.6 ±0.1	60.0 ±0.2	9.6 ±0.2	6.16
48	3	"	18.0 ±0.1	4.0 ±0.1	65.1 ±0.3	14.6 ±0.4	4.50
		Average in winter	*18.0*	*4.0*			
82	1(-62)	Whitefish (*Coregonus pidsch. Gmel.*)	0.64 ±0.01	1.2 ±0.1	4.42 ±0.07	8.3 ±0.7	0.53
83	1(-62)	Pike (*Esox lucius L.*)	2.78 ±0.05	2.9 ±0.3	11.6 ±0.2	12 ±1	0.96
		Fish, average	*1.7*	*2.0*			
51	11	Milk	0.38 ±0.10	1.5 ±0.2	3.8 ±1.0	15 ±2	0.25
52	11	"	0.114 ±0.004	1.07 ±0.05	1.14 ±0.04	11 ±1	0.11
54	12	"	0.60 ±0.01	2.1 ±0.2	4.0 ±0.1	14 ±1	0.28
55	12	"	0.47 ±0.02	2.3 ±0.3	3.1 ±0.1	15 ±2	0.20
56	12	"	0.36 ±0.02	1.4 ±0.2	3.1 ±0.2	12 ±2	0.26
57	12	"	0.10 ±0.01	2.3 ±0.2	0.70 ±0.07	16 ±1	0.04
58	12	"	0.14 ±0.01	2.7 ±0.3	1.1 ±0.1	22 ±2	0.05
59	12	"	0.27 ±0.01	1.8 ±0.1	1.9 ±0.1	13 ±1	0.15
79	12	"	0.089 ±0.006	1.6 ±0.1	0.58 ±0.04	11 ±1	0.05
		Milk, average	*0.3*	*1.9*			
60	11	Potatoes	0.012 ±0.003	4.4 ±0.2	0.07 ±0.03	25 ±1	0.003
61	11	"	0 +0.006	4.4 ±0.2	0 +0.03	25 ±1	0
66	11	"	0.034 ±0.009	5.9 ±0.2	0.15 ±0.04	25 ±2	0.006
76	11	"	0.023 ±0.007	4.3 ±0.2	0.17 ±0.05	31 ±2	0.005
77	11	"	0.022 ±0.017	4.2 ±0.3	0.12 ±0.09	22 ±2	0.005
78	11	"	0.011 ±0.009	4.5 ±0.2	0.05 ±0.04	21 ±1	0.002
		Potato, average	*0.01*	*4.6*			
		commercial:					
62	9	Cheese, "emmenthal"	0.06 ±0.01	1.2 ±0.2			0.05
63	10	" "edam"	0.053 ±0.006	0.9 ±0.1			0.06
64	9	" "emmenthal"	0.03 ±0.015	1.4 ±0.3			0.02
		Cheese, average	*0.05*	*1.2*			
65	11	Butter	0 +0.02	0 +0.3			—
81	12	Margarine, "Extra"	0 +0.03	0 +0.5			—
72	11	Wheat flour	0 +0.01	1.1 ±0.2			0
73	11	" "	0 +0.02	1.8 ±0.3			0
74	11	" "	0 +0.02	1.7 ±0.4			0
		Wheat flour average	*0*	*1.5*			0
75	11	Graham flour	0.18 ±0.03	3.3 ±0.3			0.05
68	11	Rye flour	0.14 ±0.02	5.9 ±0.3			0.02
69	11	" "	0.15 ±0.02	3.8 ±0.3			0.04
[illegible]	11	Barley flour	0.07 ±0.02	2.5 ±0.3			0.02
[illegible]	11	" "	0.08 ±0.02	3.5 ±0.3			0.02
[illegible]	11	" (local)	(0.19 ±0.06)	(7.7 ±1.2)			0.02
		Whole grain average	*0.2*	*3.8*			

[a] The accuracy is given as one standard deviation. The amount of cesium-137 and potassium is given as zero, when the calculated activity is less than one standard deviation.

600 pc/liter. During the winter great amounts of lichen stored in the summertime are given to the cattle on Lapp farms (about 1/3 of fodder eaten) (*5*).

Average Monthly Intake of Cesium–137

The average monthly intake of Cs^{137} is reported in table 4. It was calculated for the different population groups investigated by using the average monthly intake throughout the year of different foodstuffs, as given in table 1, and the average Cs^{137} content of foodstuffs described in the previous paragraphs.

A small part of the meat consumed consists of soft tissues and muscle which, according to our own results, Paakkola and Miettinen (*5*), Lidén and Bengtsson (*18*), and as those of Ekman for the goat (*19*), contain less radiocesium than shoulder. The introduced error will be of the order of a few percent.

Another factor also influencing results in the same direction is meal preparation losses. Naversten considers this to be of the order of 10 percent (*12*). Thus we know that the figures for average monthly intake of Cs^{137} may be up to 15 percent too high.

For calculation of intake of radiocesium through milk, a Cs^{137} content of 0.3 nc per liter was used. This was the average milk content of Cs^{137} in November and December of 1961.

In the case of fried fish meals, preparation losses of about 10 percent are also probable, although no losses probably take place in the case of fish soups. As can be seen in table 4, reindeer meat, fish, and milk are the main sources of Cs^{137}, all other foodstuffs comprising only 1 to 2 percent of the intake.

WHOLE-BODY COUNTING OF CESIUM-137 AND POTASSIUM

Method

The semi-portable whole-body counting equipment used at Inari was the same as that which was used at Jokkmokk in northern Sweden in September 1961 (*10*). The monitor consists of a lead shield supported by a wooden construction easily rebuilt in an identical way. The lead shield surrounds the detector in about 80 percent of the full solid angle (4π). Inside the shield is a simple chair made of plywood. The measuring geometry used is a "42-cm-chair" arrangement (figure 3) of the type developed at the Argonne National Laboratory (*20*).

The detector, a 5"x4" NaI (Tl) crystal, is connected to a transistorized 200-channel pulse amplitude analyzer.

The subject had to put on special clothes before measurement, and for this purpose we used disposable paper overalls. Each person was counted for 10 minutes. For a body weight of 70 kg, one standard deviation of the background in the Cs^{137} band corresponds to 1.6 nc Cs^{137}.

TABLE 4. ESTIMATED MONTHLY CESIUM-137 CONTENT OF THE AVERAGE DIET

Dietary group = occupation	No. of persons	Reindeer meat		Fish		Milk		Whole grain		Other foodstuffs[1]		Total
		nc	per cent	nc	per cent	nc	per cent	nc	per cent	nc	per cent	nc
Males:												
1. Lapps												
Reindeer breeders	50	*171.0*	88.3	*15.4*	8.0	*6.4*	3.3	*0.8*	0.4	*0.1*	0	*194*
Reindeer-breeding fishers	6	*164.0*	88.3	*17.2*	9.3	*3.4*	1.8	*1.1*	0.6	*0.2*	0	*186*
Lapps of other occupations	7	*79.2*	81.1	*9.4*	9.6	*7.8*	8.0	*1.1*	1.1	*0.2*	0.2	*98*
Boarding-school pupils, 16–19 yr.	4	*46.8*	81.6	*8.5*	14.8	*0.9*	1.6	*1.0*	1.8	*0.1*	0.2	*57*
Boarding-school pupils, 10–14 yr.	17	*37.8*	72.2	*5.3*	10.1	*8.2*	15.8	*0.8*	1.7	*0.1*	0.2	*52*
2. All Lapps, average	84	*130.0*	86.6	*12.7*	8.5	*6.4*	4.2	*0.9*	0.6	*0.1*	0.1	*150*
3. Non-Lapps, adults	16	*75.7*	78.7	*9.2*	9.7	*10.0*	10.4	*1.0*	1.0	*0.2*	0.2	*96*
Females:												
1. Lapps												
Reindeer breeders	33	*59.4*	77.6	*12.2*	16.0	*4.4*	5.6	*0.5*	0.7	*0.1*	0.1	*76*
Fishers	5	*21.6*	57.4	*11.4*	30.4	*3.8*	10.0	*0.7*	1.9	*0.1*	0.3	*38*
Lapps of other occupations	6	*28.8*	75.2	*4.2*	11.0	*5.0*	13.1	*0.1*	0.2	*0.2*	0.5	*38*
Boarding-school pupils, 16–19 yr.	9	*27.0*	70.3	*7.5*	19.6	*3.1*	8.1	*0.7*	1.8	*0.1*	0.2	*38*
Boarding-school pupils, 10–14 yr.	12	*28.8*	74.5	*4.2*	10.9	*4.7*	12.1	*0.9*	2.3	*0.1*	0.2	*39*
2. All Lapps, average	65	*43.2*	75.3	*9.3*	16.2	*4.2*	7.3	*0.6*	1.0	*0.1*	0.2	*57*
3. Non-Lapps, adults	15	*25.2*	70.3	*4.6*	12.8	*5.3*	14.8	*0.4*	1.1	*0.3*	1.0	*36*

[1] = Beef and pork, potato and cheese.

90

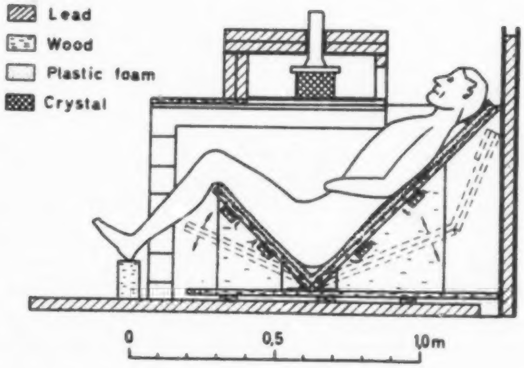


FIGURE 3.—CROSS SECTION OF THE SEMI-PORTABLE WHOLE-BODY COUNTER, SHOWING A SUBJECT IN THE CHAIR.

All backgrounds at Inari were measured with a 65 kg sugar phantom in the measuring position. The dotted curve of figure 4 shows the average background spectrum obtained.

Calibration of The Counter

The whole-body counter was constructed to have the same geometry as the "42-cm-chair" arrangement in the whole-body counter at Lund. Calibration data for the latter were therefore applicable to the semi-portable whole-body counter. As an additional check, two persons from the Lapp group were sent to Lund and were counted there again, 5 days after they had been measured at Inari. Agreement between the two sets of values was good.

In the Lund whole-body counter the average counting rate dependence of the body weight in the Cs^{137} band was found to be 4 percent per

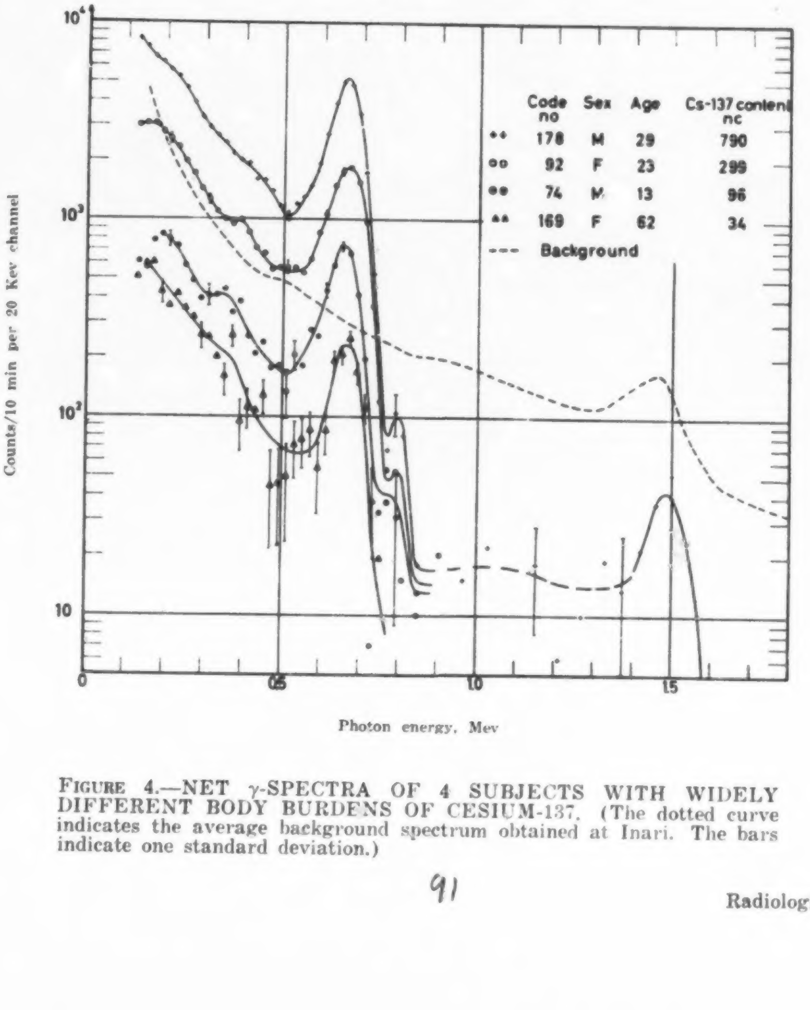


FIGURE 4.—NET γ-SPECTRA OF 4 SUBJECTS WITH WIDELY DIFFERENT BODY BURDENS OF CESIUM-137. (The dotted curve indicates the average background spectrum obtained at Inari. The bars indicate one standard deviation.)

$10^{\cdot}$ kg in the range 20 to 70 kg. The same correction factor is used also above 70 kg as a sufficiently good approximation. Very few persons at Inari had a body weight above 70 kg.

In most normal persons the contribution of potassium-40 counts in the Cs^{137} band corresponds to 1 to 2 nc Cs^{137}. We have taken this effect into account by subtracting 1 nc if the body weight is 50 kg or less, and subtracting 2 nc of Cs^{137} if the body weight is above 50 kg.

The following formula is used to evaluate the body content, A_{Cs}, of Cs^{137}.

$$A_{Cs} = \left[\frac{\text{cpm}}{2.76\,[1 + 0.004\,(70 - w)]} - \left\{ \begin{matrix} 2;\, w > 50\text{ kg} \\ 1;\, w < 50\text{ kg} \end{matrix} \right\} \right] \text{nc}^{137}\,\text{Cs}, \qquad \text{(Eq.1)}$$

where cpm is the net counting rate in the interval 0.60 to 0.72 Mev and w is the body weight (kg) of the subject.

Results

Figure 4 shows net spectra obtained from measurements of four subjects. Above 0.9 Mev the shape of the spectrum is suggested only for subject No. 178, a male reindeer breeder, who had the highest body content of cesium-137 of all the persons measured at Inari. Subject No. 92, a female of the group of reindeer breeders, had the highest value among the women. Subject No. 74 had the highest body burden of Cs^{137} of the measured persons of the group "Boarding school pupils, 10 to 14 years." Subject No. 169, a female of the group "Lapps of other professions" represents the subjects who had rather low body burdens of Cs^{137}.

Peaks or bumps at 0.66, 0.80, and 1.46 Mev from γ-rays of Cs^{137}, Cs^{134} and K^{40} are visible in all spectra, although the number of pulses from Cs^{134} and K^{40} is small.

The peaks at 0.35 Mev are typical for several spectra of the persons measured at Inari. There is also a peak at about 0.5 Mev in a few spectra. When subject No. 92 was measured in the whole-body counting facility at Lund after a thorough shower no sign of these peaks could be seen. In view of this fact it seems reasonable to assume that these peaks are a result of contamination with RaC and perhaps Ru^{106}-Rh^{106} in hair and elsewhere on the surface of the body. A small but negligible contribution might come from the I^{131} which began to appear in fall-out at the end of September 1961.

Discussion

The full results of the measurements are presented in table 5 and 6. The selection of groups is a result of the diet investigation. Owing to the earlier-mentioned effect of the body size on the background a small correction should be applied to the tabulated values, calculated on the basis of a standard background from a 65 kg phantom. For a person with a body weight of 35 kg the given values are about 2 nc too high.

It should be noticed that among adults, the body content of Cs^{137} in women is only about half that in men. This sex dependence is not pronounced among boarding school pupils. The diet investigation shows a corresponding pattern of the reindeer meat consumption.

Tables 5 and 6 also show the body burden of Cs^{137} per kg body weight for different age groups. Besides the sex difference, it is quite obvious that the highest body burdens are found in persons 20 to 40 years old. This is also in agreement with the results of the diet investigation as the meat consumption is by far the highest in this age range.

In the last column of tables 5 and 6 we have also given the average contents of potassium as obtained from whole-body counting. We corrected for the effect of the body size on the background and on the potassium calibration factor. The given error is one standard deviation (S. D.). The additional error due to the corrections is less than one S. D. except for the youngest boarding school group, where there may be an additional error of less than 0.5 g/kg because of uncertainties in the correction for the effect of body size on the background. The average body content of potassium finally obtained in the different groups is quite reasonable except for the group "Lapps of other occupations, women." Since contamination with decay products of radon was suspected, a thorough analysis of spectra was made but did not reveal any such gamma activity at all. Without further investigations of these persons it is impossible to explain this high figure.

BODY BUILD-UP OF CESIUM-137

Using the experimentally-determined Cs^{137} content of various food items previously mentioned combined with the diet study previously mentioned, it should be possible to calculate the body burden of Cs^{137} on the day of measurement. However, for this purpose the excretion rate of Cs^{137} has to be known rather accurately. Richmond, Furchner and Langham (*21*), have reported a biological half-time of 110 to 147 days from a whole-body counting study in four normal adults and recently Rundo gave 110 days as a result of his studies (*22*). None of

TABLE 5.—AVERAGE BODY CONTENT OF CESIUM-137 AND POTASSIUM IN MALE INHABITANTS OF THE INARI COUNTY, FINLAND, DETERMINED BY WHOLE BODY COUNTING ON OCTOBER 20-24, 1961

Dietary group		Number of persons studied	Average age years	Average height cm	Average weight kg	Cs^{137}, nc Average (max-min)	Cs^{137}, nc/kg Average (max-min)	g K/kg
1. Lapps								
Reindeer breeders		14	58(51-75)	160	59.5	192(383-86)	3.26(7.82-1.40)	
		10	44(40-49)	166	64.5	210(304-93)	3.35(5.68-1.53)	
		13	34(30-39)	166	65.0	327(790-103)	5.02(10.9-1.46)	
		10	23(20-28)	167	65.0	270(547-120)	4.14(7.62-1.67)	
		3	18(16-19)	162	54.5	176(312-88)	3.24(5.68-1.52)	
	Average	50	40(16-75)	164	62.7	245(790-86)	3.91(10.9-1.4)	2.4 ±0.1
Reindeer breeding fishers		3	54(51-57)	160	53.5	104(132-92)	1.96(2.20-1.56)	
		3	22(21-23)	165	71.0	115(140-97)	1.69(2.41-1.26)	
	Average	6	38(21-57)	163	62.3	110(140-92)	1.83(2.41-1.26)	2.5 ±0.1
Lapps of other occupations		3	53(46-60)	165	66.4	92(146-32)	1.31(1.97-0.58)	
		4	28(24-30)	166	63.0	157(198-118)	2.53(3.13-1.74)	
	Average	7	39(24-60)	166	64.4	129(198-32)	2.01(3.13-0.58)	2.3 ±0.1
Boarding-school pupils		4	17(16-19)	168	58.3	60(63-58)	1.04(1.16-0.91)	2.7 ±0.2
		17	11(10-13)	138	32.8	49(96-13)	1.44(2.69-0.49)	2.3 ±0.1
	Average	21	12(10-19)	144	38.0	51(96-13)	1.36(2.69-0.49)	
All Lapps,	Average	84	33(10-75)	156	56.7	178(790-13)	2.95(10.9-0.49)	
2. Local non-Lapps		3	62(56-69)	170	78.0	119(172-75)	1.52(2.14-1.16)	
		3	46(45-47)	176	70.5	52(67-42)	0.74(0.95-0.67)	
		7	32(31-36)	165	70.0	123(250-30)	1.84(3.97-0.38)	
		3	23(18-27)	165	57.4	85(97-71)	1.49(1.75-1.21)	
	Average	16	39(18-69)	168	69.3	101(250-30)	1.51(3.97-0.38)	2.2 ±0.1
Inari inhabit.	Average	100	34(10-75)	161	58.7	166(790-13)	2.73(10.9-0.38)	
3. Control group	Average	5	28(14-53)	175	75	8.4(22-1.2)	0.11(0.30-0.02)	1.9 ±0.05

TABLE 6.—AVERAGE BODY CONTENT OF CESIUM-137 AND POTASSIUM IN FEMALE INHABITANTS OF THE INARI COUNTY, FINLAND, DETERMINED BY WHOLE BODY COUNTING ON OCTOBER 20-24, 1961

Dietary group		Number of persons studied	Average age years	Average height cm	Average weight kg	Cs^{137}, nc Average (max-min)	Cs^{137}, nc/kg Average (max-min)	g K/kg
1. Lapps								
Reindeer breeders		12	±58(50-76)	148	57.0	112(206-22)	1.98(4.21-0.53)	
		10	47(42-49)	154	60.0	134(231-38)	2.27(3.85-0.68)	
		4	36(33-39)	151	47.4	66(98-39)	1.41(2.18-0.81)	
		7	22(17-26)	151	55.5	147(299-50)	2.58(4.90-0.84)	
	Average	33	44(17-76)	151	56.5	121(299-22)	2.12(4.90-0.53)	1.8 ±0.1
Fishers		5	60(48-79)	148	60.7	60(84-40)	1.04(1.40-0.59)	1.7 ±0.1
Lapps of other occupations		2	56(50-62)	149	64.0	36(38-34)	0.56(0.62-0.50)	
		2	36(36)	156	56.5	76(93-58)	1.33(1.61-1.06)	
		2	22(20-23)	156	53.0	36(55-16)	0.62(0.90-0.34)	
	Average	6	38(20-62)	154	57.8	49(93-16)	0.84(1.61-0.34)	2.5 ±0.1
Boarding-school pupils		9	17(16-19)	157	52.5	49(100-18)	0.94(1.98-0.37)	2.0 ±0.1
Boarding-school pupils								
Skolts		5	14(12-14)	148	43.1	32(51-19)	0.73(1.22-0.50)	
Breeders		7	13(13-14)	148	38.7	46(92-21)	1.22(2.30-0.52)	
	Average	12	13(12-14)	148	40.6	40(92-19)	1.01(2.30-0.50)	2.1 ±0.1
All Lapps,	Average	65	35(12-76)	151	53.4	85(299-16)	1.55(4.90-0.34)	
2. Local non-Lapps		9	62(50-83)	154	64.8	48(93-13)	0.72(1.29-0.26)	
		6	30(24-39)	158	59.4	61(162-29)	1.06(3.00-0.42)	
	Average	15	49(24-83)	156	62.6	53(162-13)	0.85(3.00-0.26)	1.6 ±0.1
Inari inhabit.	Average	80	38(12-76)	152	55.2	79(299-13)	1.42(4.90-0.26)	
3. Control group.	Average	6	32(25-46)	166	62.0	3.2(4.9-2.1)	0.05(0.065-0.038)	1.6 ±0.05

these values fit our data; for example, the 110-day value gives a diet-induced whole-body retention 2 times higher than that actually being measured. From our studies of a small group of normal Swedish adults we found an average biological half-time of 74 days for the long term retention component. By means of a temporarily changed diet we were able to study the Cs^{137} retention in 9 Swedish Lapps, 18-20 years old. This study gave an average half-time of 68 days (*23*).

The seasonal variation in meat and fish consumption has been considered when calculating the Cs^{137} body-retention. In the following calculation, 18 nc/kg has been used for the consumption of reindeer meat during the period November 1960 to August 1961 and 9 nc/kg during September and October [*cf.* Lindell (*24*)].

The daily intake of Cs^{137} via meat, fish and milk has been calculated for the groups studied, representing 98 percent or more of the total Cs^{137} content of the food. As a reasonably good estimate of the average body burden on November 1, 1960, we have used the same values obtained from the measurements at Inari on October 20-24, 1961. Corresponding to 10 percent cooking losses (see above), a "cooking factor" k = 0.9 has been used in the calculations.

Using a two-exponential retention function, we can describe the Cs^{137} retention sufficiently accurately for our purpose by means of the following equation:

$$A_r = A_0 e^{-(k_2 + \lambda)t} + \frac{pa}{k_1}\left[1 - e^{-k_1 t} \right] + \frac{(1-p)a}{k_2 + \lambda}\left[1 - e^{-(k_2 + \lambda)t} \right] \quad \text{(Eq. 2)}$$

where the symbols indicate:

A_r = whole-body retention at the time t, nc
A_0 = the body burden of Cs^{137} at $t = 0$, nc
a = the constant daily intake of Cs^{137}, nc per day
λ = physical decay constant of Cs^{137}
k_1 = fast biological fractional excretion rate of Cs^{137} per day
k_2 = slow biological fractional excretion rate of Cs^{137} per day
p = fraction of a single administration being excreted with the fractional rate k

As k_1 is about 50 times larger than k_2 and p equals only 0.12, it is evident that the second term in equation 2 can be ignored. The physical decay constant λ is roughly 1 percent of k_2 and therefore a negligible error is introduced if λ is omitted in the first and third terms of equation 2, the final form of which then is as follows:

$$A_r = A_0 e^{-k_2 t} + \frac{(1-p)a}{k_2}\left[1 - e^{-k_2 t} \right] \quad \text{(Eq. 3)}$$

The value a is corrected for cooking losses; a varies with the season. The numerical treatment of equation 3 is performed separately for each period having a constant daily intake a. In table 7, a is given for the three groups of persons for which a calculation of the dietary build up of Cs^{137} is performed.

The data of table 7 have been used in an attempt to obtain the value of the long excretion rate k_2 giving the best fit to the experimentally measured average whole-body retention (table 8).

The adult reindeer breeder groups are large and the result of the corresponding diet study is considered to be accurate within ± 10-percent (*7*). Thus it should be a rather good estimate, assuming an average long term excretion rate of Cs^{137} in adult Finnish Lapps (men and women 17 to 75 years old), corresponding to a half-time of 65 ± 10 days. This value is rather close to the half-time of 68 days for Swedish Lapps, reported above, but both figures are smaller than any other average half-time hitherto reported in the literature for Cs^{137} in adult humans. Thus, there is also a fair chance that the half-time of the Cs^{137} retention in 10-14 year old boys (Finnish Lapps) is to be found within the range $T_{1/2} = 44 \begin{smallmatrix} +10 \\ -5 \end{smallmatrix}$ days.

It is interesting to study the seasonal varia-

TABLE 7.—DAILY CESIUM-137 INTAKE FOR SOME LAPP GROUPS

[Intake per person in nc/day]

Period	Reindeer breeders		Boarding school children 17 boys 10–14 y
	50 men 16–75 y	33 women 17–76 y	
10/21/60—4/30/61	9.3	3.18	1.96
5/1/61—7/31/61	2.34	1.41	1.84
8/1/61—8/31/61	1.65	0.90	0.85
9/1/61—9/30/61	1.71	0.96	0.59
10/1/61—10/20/61	2.22	1.35	0.60

TABLE 8.—THE BIOLOGICAL HALF-TIME OF CESIUM-137 FOR SOME LAPP GROUPS, GIVING THE BEST FIT TO THE EXPERIMENTALLY MEASURED WHOLE-BODY RETENTION

Group	Measured body burden Oct. 20, 1961 (nc)	Half-time (best fit) [days]
Reindeer breeders:		
Men	245	64
Women	122	65.5
Boarding school boys, 10-14 yrs.	49	44

tion of whole-body retention of Cs^{137}, applying the excretion rate constants obtained above. For the well-represented group "reindeer breeder," figure 5 shows how the body activity of men and women varied in the period from October 21, 1960, to October 20, 1961. At the time of measurement we evidently obtained the minimum value for the year. The maximum body burden of men, 790 nc, is 2.9 times higher than the measured value; for women with a maximum value of 245 nc, the same ratio is 2.0. It is desirable that these theoretically derived data be subjected to verification by means of direct whole-body counting of Lapps at the end of April, if the diet habits remain unchanged. Recently performed studies (May, 1962) by Miettinen *et al.* (*25*) show results in approximate agreement with the predicted values.

THE RADIATION DOSE FROM THE BODY CONTENT OF CESIUM-137

The approximately uniformly distributed radiocesium irradiates the body tissues through its gamma and beta radiation. The radiation dose per unit activity and unit body weight, $r_{w,l}$, varies with the weight w and the height l of the body, since both affect the efficiency of the gamma absorption within the body. This effect can be taken into account by using proper geometrical factors for gamma radiation according to Loevinger *et al* (*26*). Assuming an emission of 0.85 γ-photons per disintegration (*27*) we obtain a dose contribution from β-rays + conversion electrons ($r^{\beta}_{w,l}$) and from γ-rays + X-rays ($r^{\gamma}_{w,l}$) as given in table 9. As the radiation dose is proportional to the time integral of equation 2—that is, to the area under the retention function in figure 5 the annual radiation dose D can be calculated with sufficient accuracy by means of the following expression:

$$D = \frac{r_{w,l}}{365 \cdot w \cdot k_2} \sum_n \Big[(1 - e^{-k_2 t}) \, (A_{0,n} - \Big(\frac{(1-p)a_n}{k_2} \Big) + (1-p)a_n \cdot t \Big] \quad \text{(Eq. 4)}$$

where

$r_{w,l}$ = dose constant for cesium-137 at a concentration of one nc/kg in a subject of height l cm and weight w kg (mrad/yr)

a_n = the constant daily intake of cesium-137 in the nth period (nc/d)

$A_{0,n}$ = the Cs^{137} burden at the beginning of the nth period (nc)

The dose D_{min} of table 10 is obtained from the assumption that the measured body burden is unchanged for one year; it should serve as an approximate lower limit for the annual dose.

The large consumption of reindeer meat by men during November to April results in a total dose which is 2.0 times higher than the minimum value D_{min}. For women, and for boys

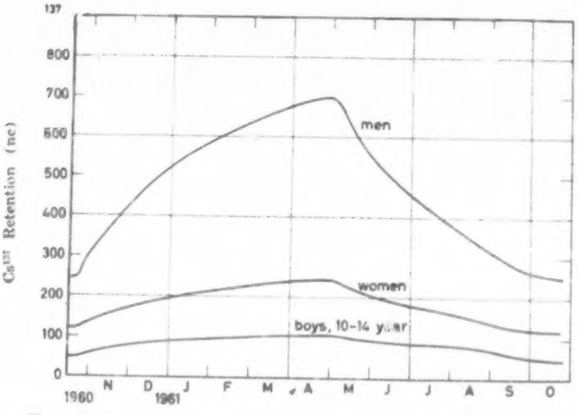


FIGURE 5.—CESIUM-137 RETENTION IN FINNISH LAPPS FROM NOVEMBER 1960 TO OCTOBER 1961 AS CALCULATED FROM THE INTAKE OF CESIUM-137 THROUGH FOOD

TABLE 9.—ANNUAL RADIATION DOSE FROM CESIUM-137 IN A HUMAN SUBJECT AT A SPECIFIC ACTIVITY OF ONE NC PER KG BODY WEIGHT

Weight w (kg)	Height l (cm)	β-dose $r^{\beta}_{w,l}$ (mrad/yr)	γ-dose $r^{\gamma}_{w,l}$ (mrad/yr)	total dose $r_{w,l} = r^{\beta}_{w,l} + r^{\gamma}_{w,l}$ (mrad/yr)
35	140	4.5	2.9	7.4
70	170	4.5	3.5	8.0
100	170	4.5	4.0	8.5
∞	—	4.5	10.6	15.1

95

TABLE 10.—THE ANNUAL IRRADIATION IN THREE GROUPS OF FINNISH LAPPS FROM THE INTERNALLY ACCUMULATED CESIUM-137 ACTIVITY

	Body burden of Cs^{137} [nc]		Annual dose as estimated from	
	observed Oct. 20, 1961 ($A_{r,obs}$) [nc]	calculated average value Oct. 20, 1960 to Oct. 20, 1961 ($A_{r,ave}$) [nc]	observed body burden $A_{r,obs}$ D_{min} [mrem]	calculated cesium-137 buildup D [mrem]
Men	245	485	31	62
Women	122	187	17	26
Boys, 10-14 y.	49	84	11	19

10-14 years old, the same ratio is smaller, being 1.5 and 1.7, respectively, owing to a lower winter consumption of reindeer meat.

The highest annual radiation dose produced by the Cs^{137} contamination is found among the reindeer breeders. The average annual dose of this group for the year November 1960 to October 1961, 60 mrem, means that the gonads and other soft tissues obtain a *total* dose approximately 1.6 times the average Scandinavian gonad and soft tissue dose from natural sources, 95 mrem (*28*). In the same group the estimated maximum dose is 120 mrem, and the corresponding factor is then 2.3. Considering the annual contribution of approximately 20 mrem from internal sources only (K^{40} and C^{14}), there is an increase in the gonad and soft tissue dose from internal radioactive sources by a factor of 3 and 6, respectively.

For women the doses D and D_{min} are generally only 50 percent or less of the dose to men of the same group.

Reindeer breeders and their families are not the only consumers of reindeer meat; many non-Lapps consume large quantities of this food. A maximum dose figure of 70 mrad for men in the local non-Lapp group was obtained.

Generally the International Commission on Radiological Protection figures on the genetic dose, 5 rem per 30 years, (*29*, *30*) should be applicable only to large populations. However, the group of Lapps in Finland is a rather isolated one with a high percentage of intermarriages. Obviously, the final answer to the question, if it may be reasonable to consider the Lapps as "a large population," has to be given by geneticists.

The maximum individual dose from cesium-137 in the investigated group of Lapps is estimated to be 120 mrem. This is one-fourth of the maximum permissible individual dose of 500 mrem per year.

If a substantial increase of the contamination level of Lapps were to occur or can be suspected in the future, the radiation hygiene of this relatively small population group might be subject to further consideration.

COMPARISON OF CORRESPONDING SWEDISH AND FINNISH LAPP GROUPS

When comparing the results of the Inari investigation with that made in Jokkmokk, Sweden, in September 1961, differences between comparable groups are obtained as shown in table 11.

For adult reindeer breeders (men and women), there is roughly a 50 percent higher body burden of Cs^{137} in Swedish Lapps than in Finnish Lapps. For children the difference is greater, showing an activity ratio (Swedes to Finns) of more than 2. This fact is probably a result of the summer diet of Swedish Lapp children, since they eat more reindeer meat than Finnish Lapp children. During the autumn and winter there is no reason to suspect any great difference in reindeer meat consumption between corresponding Lapp groups in Finland and Sweden. The data from measurements of reindeer meat also indicate approximately the same activities of Cs^{137}. It is therefore probable that the activity of Cs^{137} retained in Lapps in April 1961 should be roughly the same in Finland and Sweden. However, during the summer, substantially less reindeer meat per capita is consumed in Finland than in the

TABLE 11.—BODY BURDENS OF CESIUM-137 IN FINNISH AND SWEDISH LAPPS

		Body activity of cesium-137 (nc)		Activity ratio Jokkmokk: Inari
		Inari, Oct. -61 average (max-min)	Jokkmokk, Sept. -61 average (max-min)	
Lapps				
Reindeer breeders	M[a]	245 (790–86)	328 (689–137)	1.34
	F[a]	121 (299–22)	213 (368–151)	1.76
Non-reindeer-breeders	M	129 (198–32)	172 (333–48)	1.33
	F	49 (93–16)	136 (207–45)	2.77
Lapp children (10-14y)	M	49 (96–13)	99 (139–78)	2.02
	F	40 (92–19)	93 (154–60)	2.32
Local non-Lapps	M	101 (250–30)	[b] 70 (121–)	0.69
	F	53 (162–20)	47 (130–12)	0.89

[a] M = men, F = women.
[b] Minimum detectable amount = 15 nc Cs^{137}.

Jokkmokk area. This fact explains the higher values in Jokkmokk in September 1961.

SUMMARY

A field study of the contents of Cs^{137} and potassium in the diets and bodies of 190 Lapps and other inhabitants of the Inari county in northern Finland was carried out in October 1961. The human material was obtained from 8 main living areas of Lapps in different parts of this large county.

The investigation includes determination of the Cs^{137} and potassium contents of samples of the most important constituents of the diet. The diet of each individual was investigated by means of the interview method. The intake of Cs^{137} and potassium through the food was calculated.

During the winter (1960-1961) reindeer meat showed an average Cs^{137} content of 18.0 nc/kg fresh weight. In the autumn of 1961 lower values were found. In pike the Cs^{137} content was found to be 2.8 nc/kg fresh weight and in milk up to 0.6 nc/kg. The amount of radiocesium in reindeer meat, fish, and milk was found to contribute 98 to 99 percent of the total dietary intake of Cs^{137}.

The highest body burden observed in a reindeer-breeding Lapp was 790 nc Cs^{137}. On the average the male reindeer-breeding Lapps contained 245 nc Cs^{137}, while corresponding females and children had an average of 122 nc Cs^{137} and 51 nc Cs^{137}, respectively. The body burdens are found to be mainly a function of the Cs^{137} intake. Twice as high average body burdens as those mentioned are predicted to occur in April through May 1962. From the dietary data of the year preceding the dates of measurement and the obtained body burden of Cs^{137} an excretion rate corresponding to a biological half-time of 65 days for adult Lapps was found; for children the figure was 44 days.

The annual radiation dose from the body burden of Cs^{137} has been estimated to be 62 mrem for men, 26 mrem for women and 19 mrem for children, all in the reindeer-breeding group. The intake of potassium in the diet and the average body content of potassium in the different occupational groups were also determined. Finally, a comparison between the Cs^{137} content of Swedish and Finnish Lapps is made.

ACKNOWLEDGEMENTS

We are deeply grateful to Dr. R. C. McCall for valuable assistance in the whole body counting at Inari, to Mr. G. Bengtsson for the development of the sample measuring procedure and Mr. E. Häsänen for carrying out the sample measurements with Mr. Bengtsson.

We gratefully acknowledge the Finnish Atomic Energy Commission, the Swedish Atomic Energy Research Council and the Division of Radiological Health, Bureau of State Services, Public Health Service, U.S.A. for grants which made the investigation possible.

REFERENCES

(*1*) Paakkola, O., R. Nasanen, D. Merten, and J. K. Miettinen: *Ann. Acad. Sci. Fennicae, Ser. A, II. Chemica, No. 101*:1 (1960).

(*2*) Miettinen, J. K., O. Paakkola, R. Nasanen, A. Vuorinen, and D. Merten: Strontium-90 and Cesium-137 in Grass and Milk in Finland During 1959, *Nature, 189*:324-325 (1961).

(*3*) Virkkunen, V-E. J. and A. P. U. Vuorinen, *Suomen Kemistilehti B 35*:35 (1962).

(*4*) Vuorinen, A. P. U., and J. K. Miettinen, *Ann. Acad. Sci. Fennicae, Ser. A. II Chemica, No. 102*:1 (1960).

(*5*) Paakkola, O. and J. K. Miettinen: Strontium-90 and Cesium-137 in Plants and Animals in Finnish Lapland During 1960, *Ann. Acad. Sci. Fennicae, Ser. A. II Chemica No. 125*:1 (1963).

(*6*) Salo, A. and J. K. Miettinen: article in press for *Nature.*

(*7*) Jokelainen, A., M. Pekkarinen, P. Roine, and J. K. Miettinen: Z. *fur Ernahrungswiss., 3*:110 (1962).

(*8*) Baarli, J., K. Madshus, K. Liden, and R. C. McCall: Radiocesium and Potassium in Norwegians, *Nature 191*:436-438 (1961).

(*9*) Liden, K.: Cesium-137 Burdens in Swedish Laplanders and Reindeer, *Acta Radiol., Vol. 56*:237-240 (Sept. 1961).

(*10*) Naversten, Y., R. C. McCall, and K. Liden: *Acta Radiologica, Ther. Phys. Biol. 1*:190 (1963).

(*11*) Liden, K. and Y. Naversten, (1962). (see ref. 14)

(*12*) Abstracts of Communications, Second Northern Meeting on Radioactive Food Chains, Helsinki, April 2-3, 1962, Helsinki (1962).

(*13*) Second Symposium on Radioactivity in Man, Chicago, Sept. 5 to 7, 1962, (In press).

(*14*) Liden, L., and I. O. Andersson: Cesium-134 in Man, *Nature, 195*:1040-43 (1962).

(*15*) Hvinden, T. and A. Lillegraven: *Nature, 192*:1144 (1962).

(*16*) Liden, K., unpublished, (1962).

(*17*) Medicinalstyrelsens stralskyddsnamnd: *Samordning av radioaktivitetsmatningar pa livsmedel.* 87 pages, Stockholm (1962).

(*18*) Liden, K. and G. Bengtsson, unpublished.

(*19*) Ekman, Lars: Distribution and Excretion of Radio-Cesium in Goats, Pigs and Hens, *Acta Veterinaria Scandinavia, 2:* Suppl. 4, 1-83 (1961).

(*20*) Miller, C. E.: Long-Term Retention of Radiocesium by Man, *Proc. of the Second United Nations Int. Conf. on the Peaceful Uses of Atomic Energy,* Vol. 23:201-205, Geneva (1958).

(*21*) Richmond, C. R., J. E. Furchner, and W. H. Langham: Long-Term Retention of Radiocesium by Man, *Health Physics, 8*:201-205 (1962)

(*22*) Rundo, J. and B. Newton: Some Recent Measurements of Cesium-137 and Zirconium-95 In Human

Beings, *Nature*, *195*:851-854 (1962).

(*23*) Liden, K. and Y. Naversten, in preparation, 1963.

(*24*) Lindell, B., private communication.

(*25*) Miettinen, J. K., E. Hasanen, and A. Salo, unpublished, 1963.

(*26*) Loevinger, R., J. G. Holt, and G. J. Hine, in G. J. Hine: Internally Administered Radioisotopes, G. J. Hine and G. L. Brownell, Editors, *Radiation Dosimetry*, p. 801. Academic Press Inc., New York (1958).

(*27*) Nuclear Data Sheets, NRC 61-2-133 and NRC 61-2-134, *Nat. Res. Counc.*, Washington (1961).

(*28*) United Nations: *Report of the United National Scientific Committee on the Effects of Atomic Radiation (A/3838)* p. 56, New York (1958).

(*29*) International Commission on Radiological Protection: *Recommendations of the International Commission on Radiological Protection*, September 9, 1958. Pergamon Press, New York (1959).

(*30*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

STRONTIUM TURNOVER RATES IN HUMAN BONES [1]

Joseph Rivera [2]

The concentrations of Sr^{90} in vertebra, rib and femur shaft specimens from each of twelve accident victims were reported in *HASL-135* (*1*). These specimens have now been analyzed for stable strontium and the results are presented in table 1.

The average stable strontium concentration in vertebrae was 91 ± 12 $\mu g/g$ of ash[3] in ribs 108 ± 21 $\mu g/g$ of ash, and in femur shafts 116 ± 24 $\mu g/g$ of ash. An analysis of variance was performed on the data to see if there were significant differences in the strontium concentrations among the three bones. It was found that in the same individual a small but significant difference at the 95 percent confidence level existed between the concentration in vertebra and rib, and in vertebra femur shaft, but there was no significant difference between rib and femur shaft concentrations (see table 2).

Despite the fact that vertebrae had lower stable strontium concentrations than ribs or femur shafts, the Sr^{90} concentrations in vertebrae were higher than those in ribs or femur shafts in March 1962. This apparently anomalous situation can be explained if the turnover rate of strontium in vertebrae is greater than that in ribs or femur shafts.

TABLE 1. STABLE STRONTIUM CONCENTRATIONS AND SPECIFIC ACTIVITIES OF VERTEBRAE, RIBS AND FEMUR SHAFTS, MARCH 1962

Individual	Vertebrae		Ribs		Femur shafts	
	μg Sr/g ash	pc Sr^{90}/mg Sr	μg Sr/g ash	pc Sr^{90}/mg Sr	μg Sr/g ash	pc Sr^{90}/mg Sr
1	80	3.00	137	0.69	147	0.22
2	110	2.27	118	1.03	122	0.74
3	85	2.82	87	1.20	88	0.77
4	102	3.53	115	2.27	112	2.62
5	86	4.65	82	2.96	97	3.02
6	96	2.19	110	2.45	121	1.26
7	80	3.75	92	1.82	89	1.01
8	110	2.18	137	1.09	152	0.71
9	99	1.72	103	1.88	112	2.25
10	75	2.80	93	3.73	112	1.01
11	87	3.10	90	1.36	93	0.73
12	85	2.59	137	0.89	153	0.53
Average	91	2.88	108	1.78	116	1.24
Standard deviation	12	0.82	21	0.93	24	0.89

Estimates of Strontium Turnover Rates

A rough estimate of the strontium turnover rate of a given bone can be made if it is assumed that each year a fixed fraction of the total bone strontium, with a specific activity W_{n-1}, is resorbed and replaced with an equal amount of strontium from the diet having a specific activity of Z_n. This may be expressed more succinctly by the following equation:

TABLE 2.—RATIOS OF STABLE STRONTIUM CONCENTRATIONS IN THREE HUMAN BONES, MARCH 1962

(12 individuals)

Ratio	Average	95 percent confidence limits	
		Lower limit	Upper limit
Vertebrae/Ribs	0.85	0.77	0.94
Vertebrae/Femur shafts	0.79	0.72	0.88
Ribs/Femur shafts	0.93	0.84	1.03

$$W_n = W_{n-1} + f\,(Z_n - W_{n-1})$$

Where W_n is the specific activity of the bone at the end of year 'n', W_{n-1} is the specific activity of the bone at the end of the year 'n-1', 'f' is the fraction of the bone strontium pool turned over during the year and Z_n is the specific activity of the diet during the 'n' year.

If W_n is known for any year 'n' and Z_n can be estimated for the years preceding 'n,' then a best value of 'f' can be found to fit the data.

The bone samples obtained in this study were from individuals between 35 and 65 years of age who resided in the Metropolitan New York area prior to their accidental death in March 1962. Data are available to make reasonable estimates of the specific activity of New York diets for 1956, 1957, 1958, 1959, 1960, and 1961. These estimates are 4, 4, 7, 9, 7 and 7 pc Sr^{90}/mg strontium, respectively. The specific activity of the diet prior to 1956 is assumed to have been negligible compared to that after 1955.

These values were used as Z_1, Z_2, Z_3, Z_4, Z_5, and Z_6 and substituted successively in the equation assuming different values of 'f'. The calculated specific activity (W_6) corresponding to different values of 'f' are plotted in figure 1.

---

[1] Data from *Fallout Program Quarterly Summary Report, HASL-140*:303-5, Office of Technical Services, Department of Commerce, Washington 25, D. C. (October 1, 1963) price $4.00.

[2] Mr. Rivera is a physicist, Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York 14, New York.

[3] ± values indicate one standard deviation of samples from the mean.

Using the average values of specific activity in vertebrae, ribs and femur shafts from table 1, the estimated annual turnover rates from figure 1 are 9 percent, 5 percent, and 4 percent, respectively.

Strontium Biological Half-life in Skeleton

Based on the results obtained when two adult human skeletons were ashed in this laboratory, the ash weights of vertebrae, ribs, and femur shafts were 10 percent, 6 percent, and 10 percent, respectively, of the ash weight of the total skeleton. Using these fractions as weighting factors, the average turnover rate for 26 percent of the skeleton is calculated to be about 6 percent per year. If this value is used for the skeleton as a whole, the calculated biological half-life for strontium in the skeleton is 11.6 years or 4,200 days, which is lower by a factor of about four than the figure of 1.8 x 10^4 days given in the report of ICRP Committee II (*2*).

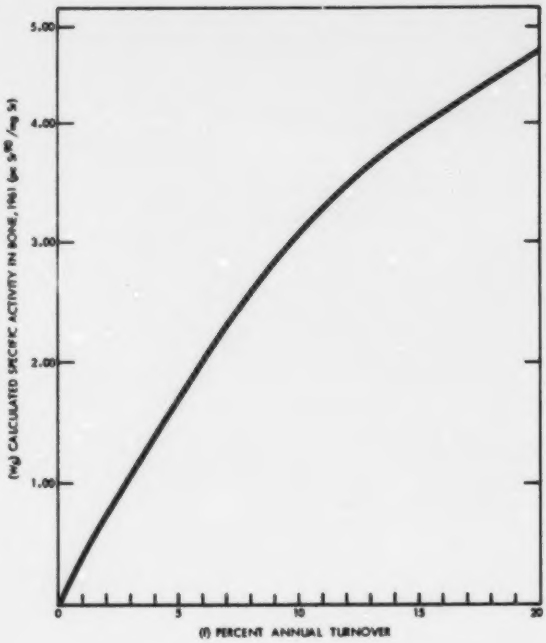


FIGURE 1.—ESTIMATED ANNUAL TURNOVER RATES OF STRONTIUM-90 IN BONE AT NEW YORK

REFERENCES

(*1*) Rivera, J. and L. D. Y. Ong: Strontium-90 Concentrations in Three Bones of the Human Skeleton, *Fallout Program Quarterly Summary Report, HASL-135*:276-9, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963) price $4.00.

(*2*) International Commission on Radiological Protection: Report of Committee II on Permissible Dose for Internal Radiation (1959), *Health Physics, 3*:1-380 (June 1960).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Brookhaven National Laboratory and Rocky Flats Plant.

The measured concentration of a radionuclide in air and water may be compared with the Maximum Permissible Concentration (MPC) of that nuclide as recommended by the National Committee on Radiation Protection and Measurement (NCRP). For the environment near an AEC installation, the applicable MPC's are one-tenth of the occupational MPC values for continuous exposure given in the National Bureau of Standards "Handbook 69" (*1*). The MPC values applicable to the following reports are given in table 1.

In the following reports, the use of nonspecific terms such as "total activity," "total alpha," and "gross beta" do not in themselves suggest any one MPC value. Often, when concentrations are low, a laboratory will assign an MPC value that is more restrictive than

100

TABLE 1. SELECTED ENVIRONMENTAL MPC VALUES PERTAINING TO AEC INSTALLATION REPORTS

Line no.	Radionuclide or mixture of unknown nuclides	Environmental MPC's	
		Water ($\mu\mu c$/liter)	Air ($\mu\mu c/m^3$)
1	If Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present [a]	3,000	—
2	If Sr^{90}, Pb^{210}, Ra^{226}, Ra^{228} are not present [a]	600	—
3	If Ra^{226}, Ra^{228} are not present [a]	100	—
4	Mixture of unidentified nuclides	10	0.04
5	If α emitters and Ac^{227} are not present [a]	—	1.0
6	If α emitters and Pb^{210}, Ac^{227}, Ra^{228}, Pu^{241} are not present [a]	—	10
7	If α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present [a]	—	100
8	Argon-41 (immersion)	—	40,000
9	Plutonium-239	5,000	0.06
10	Uranium-natural	20,000	2

[a] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to recent AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than $\frac{1}{10}$ and if the sum of these ratios for the group in question is equal to or less than $\frac{1}{4}$.

necessary. This avoids the more costly isotopic tests necessary to justify a less restrictive value.

1. Brookhaven National Laboratory, July 1962-June 1963

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: (1) by discharge of coolant air from the graphite research reactor, (2) by radiation from an ecology forest gamma source, and (3) by the discharge of low level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (see figure 1).

Area Monitoring

The radioactivity in the discharge coolant air is almost entirely that of argon-41, a beta-gamma emitter. Because the most critical exposure to argon-41 is that of external gamma, the monitoring is performed by measuring the dose-rate in milliroentgens per week (mr/wk) rather than the concentration in air. Late in 1961 a 10,000 curie cesium-137 gamma source was installed in the ecology forest about 800 meters equidistant from the north and east boundaries (*2*).

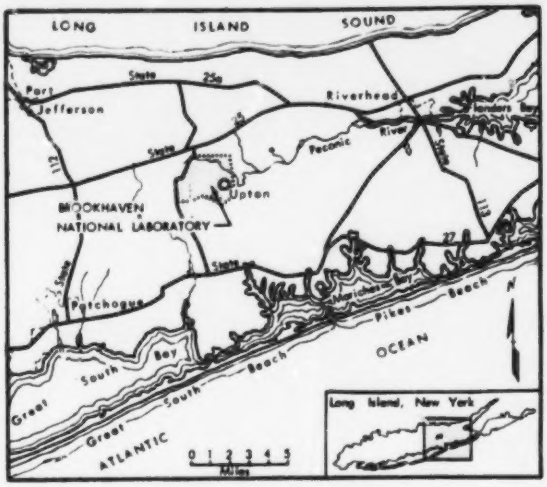


FIGURE 1.—BROOKHAVEN NATIONAL LABORATORY AND SURROUNDING AREA

Table 2 presents the average external gamma

TABLE 2.—EXTERNAL GAMMA LEVELS AT BNL SITE BOUNDARY

[Average exposure dose rates in mr/wk]

Period	North gate [1]	Southwest perimeter	Southeast perimeter	Northeast perimeter
Gamma dose from laboratory operations [2]				
1962				
July	0.34	0.17	0.44	3.73
August	0.79	0.42	0.28	3.05
September	0.38	0.35	0.24	3.84
October	0.36	0.28	0.73	2.86
November	0.22	0.53	0.60	2.30
December	0.14	0.45	0.39	1.96
1963				
January	0.45	0.26	0.28	2.33
February	0.06	0.4	0.76	2.23
March	0.58	0.05	0.57	2.28
April	0.14	0.19	1.08	2.51
May	0.43	0.24	0.41	3.28
June	0.82	0.32	0.57	2.65
Second half 1962	0.38	0.38	0.44	2.78
First half 1963	0.41	0.19	0.60	2.57
Undisturbed background				
Second half 1962	3.99	3.37	3.57	4.26
First half 1963	4.81	4.37	4.61	5.21

[1] North gate station is located 680 meters inside boundary. The others are on the boundary.

[2] Gamma dose from laboratory operation is due almost entirely to argon-41 from reactor cooling air, except at the northeast perimeter station which receives additional radiation from the ecology forest gamma source.

dose rates measured at the four stations shown in figure 2. The higher levels at the Northeast perimeter station are primarily due to the ecology forest source. The environmental maximum permissible dose recommended by NCRP is 0.5 rem/yr, (10 mrem/wk) above natural background, averaged over a one-year period.

Water Monitoring

The BNL liquid waste effluent is monitored for gross beta concentrations at the site boundary. Table 3 presents the average concentration together with the total activity released as determined by using known effluent flow rates.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*February 1961*
Third and fourth quarters 1960	*June 1961*
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*June 1962*
First and second quarters 1962	*January 1963*

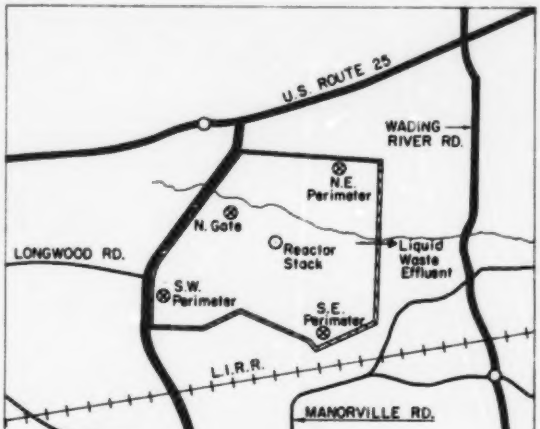


FIGURE 2.—BROOKHAVEN NATIONAL LABORATORY MONITORING STATION LOCATIONS

TABLE 3.—GROSS BETA ACTIVITY IN BNL LIQUID WASTE EFFLUENT

Period	Average beta concentration (pc/liter)	Total beta activity discharged (mc)
1962		
July	110	8.6
August	150	11.4
September	140	10.5
October	100	7.8
November	120	9.6
December	110	7.9
1963		
January	135	10.0
February	84	6.3
March	73	6.9
April	101	9.7
May	81	4.7
June	82	4.1
Second Half 1962	120	55.3
First Half 1963	92	41.7

2. Rocky Flats Plant
July 1962-June 1963

Dow Chemical Company,
Denver, Colorado

The Rocky Flats Plant (RFP) is engaged in plutonium fuel element fabrication under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 3. To assure properly controlled release of radioactive materials to the environment, water, air, and vegetation are sampled periodically and analyzed for gross alpha activity. The most active material involved in the process is plutonium.

Because the plant is located on gravel washed out of the highly mineralized Front Range of the Rocky Mountains, heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil of the area and are measurable in most samples of air, water, and vegetation as well.

Air Monitoring

Continuous 24-hour air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha activities are shown in table 4. The alpha activity is believed to

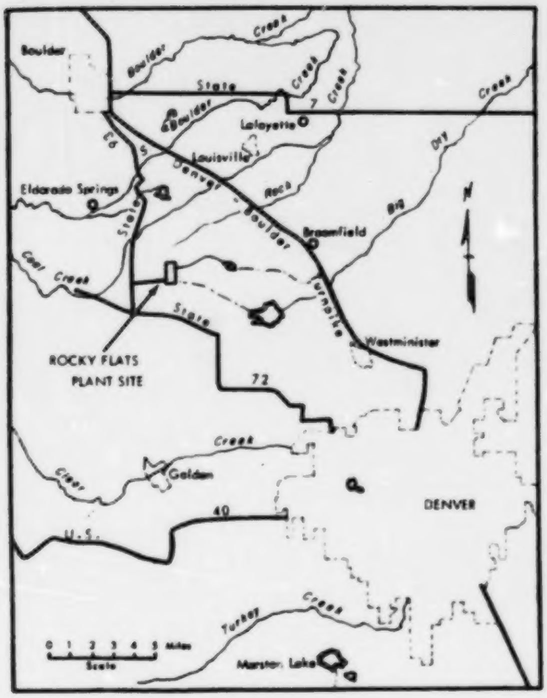

Boulder
Boulder
Creek
State
Creek
7
Creek
Creek
Boulder
Lafayette
Louisville
Eldorado Springs
Denver
Boulder
Rock
Dry
Big
Broomfield
N
State
Coal
Creek
Turnpike
State
Westminister
ROCKY FLATS
PLANT SITE
72
Creek
Clear
Golden
DENVER
40
U.S.
Turkey
Creek
0 1 2 3 4 5 Miles
Scale
Marston Lake

FIGURE 3.—LOCATION OF THE ROCKY FLATS PLANT ENVIRONMENT, DENVER, COLORADO

consist entirely of airborne naturally occurring uranium minerals.

TABLE 4.—LONG-LIVED ALPHA ACTIVITY IN PARTICULATES IN AIR, ROCKY FLATS PLANT

Month	Average alpha concentration (pc/m³)
1962	
July	< 0.001
August	< 0.002
September	< 0.001
October	< 0.001
November	< 0.002
December	< 0.001
1963	
January	< 0.003
February	< 0.004
March	< 0.002
April	< 0.004
May	< 0.003
June	< 0.004

Water Monitoring

Water samples were collected semi-monthly from four reservoirs at distances ranging from 3 to 8 miles from the plant. The average alpha concentrations in the four reservoirs during the second half of 1962 and first half of 1963 are shown in table 5.

Non-routine raw surface water samples were collected from a number of outlying streams and lakes during fall and spring vegetation collections. Samples collected during the second half of 1962 (34 samples) had an average gross alpha activity of 1.0 pc/liter. The 23 first half 1963 samples averaged 2.9 pc/liter.

Vegetation Samples

A total of 204 vegetation samples collected during 1962 were analyzed during the 12 month period covered by this report. The average gross alpha activity of 161 samples collected less than 3 miles from the plant was 127 pc/kg (dry). The 43 samples collected at distances from 3 to 18 miles averaged 121 pc/kg (dry).

Previous coverage in *Radiological Health Data*:

Period	Issue
Second half 1960 and First half 1961	*November 1961*
Second half 1961	*May 1962*
First half 1962	*January 1963*

TABLE 5.—ALPHA ACTIVITY IN RESERVOIRS IN THE VICINITY OF ROCKY FLATS PLANT

(Average concentrations in pc/liter)

Reservoir	Second half 1962	First half 1963
Great Western	2.8	3.1
Standley	2.3	3.0
Baseline	1.7	1.8
Ralston	3.5	2.3

REFERENCES

(*1*) National Committee on Radiation Protection: *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (June 5, 1959). Price 35 cents.

(*2*) Hull, A. P.: 1962 Environmental Radiation Levels at Brookhaven National Laboratory, BNL 807 (T-310) (Health and Safety—TID—4500, 21st Ed.) May 1963, Office of Technical Services, Department of Commerce, Washington, D. C. 20430, price $.50.

REPORTED NUCLEAR DETONATIONS, JANUARY 1964

During January 1964, the United States Atomic Energy Commission continued underground testing at the Nevada Test Site, conducting one test of low intermediate yield (20-200 kilotons) on January 16, and another of low yield (less than 20 kilotons) on January 23. Arbitrary reference numbers 148 and 149 were assigned by *Radiological Health Data* in the respective order of the test dates.

RADIOLOGICAL HEALTH DATA

VOLUME V, NUMBER 3
MARCH 1964

TABLE OF CONTENTS

Page

SECTION I.—AIR AND FALLOUT

Fission Product Beta Activity in Airborne Particulates and Precipitation 105
1. Radiation Surveillance Network (November 1963), PHS 105
2. Canadian Air Monitoring Program (November 1963) 109
3. Mexican Air Monitoring Program (November 1963) 110
4. Pan American Air Sampling Program (November 1963), PAHO and PHS 111
5. Gross Beta Activity in Air, North America (November 1963) 111
Fission Product Gamma Activity in Air—80th Meridian Network (October 1963), AEC 113

SECTION II.—MILK AND FOOD

Milk Surveillance 115
1. Pasteurized Milk Network (November 1963), PHS 115
2. California Milk Network (July—September 1963) 120
3. Florida Milk Network (November 1962—December 1963) 121
4. Indiana Milk Network (November 1963) 122
5. Pennsylvania Milk Network (September 1962—November 1963) 123
6. Canadian Milk Network (November 1963) ... 124
Moving Annual Average Radionuclide Concentrations in Pasteurized Milk (December 1962—November 1963), PHS 126
The Analytical Quality Control Service of the Division of Radiological Health—Interlaboratory Study of Iodine-131 Surveillance Measurements in Milk, Marvin Rosenstein and Abraham S. Goldin 128
Radionuclides in Institutional Diet Samples (July—September 1963), PHS 131
Tri-City Diet Study (May—July 1963), AEC 137

SECTION III.—WATER

Radioactivity in Surface Waters of the United States (September 1963), PHS 139
Radioactivity in California Surface Water (January—June 1963) 143

SECTION IV.—OTHER DATA

Iodine-131 in *Post-Mortem* Human Thyroids, Frances I. Visalli and Abraham S. Goldin 145
Environmental Levels of Radioactivity at Atomic Energy Commission Installations 149
Shippingport Atomic Power Station (July 1962—June 1963) 149
Reported Nuclear Detonations (February 1964) ... 150

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I.—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Early indications of possible increases of fission product activity in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure resulting from fallout, but it does form a basis for an alerting system and is useful in determining when and where to conduct more extensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

November 1963 data from three networks were combined and are presented graphically by means of isogram lines on a map of North America (figure 5).

1. Radiation Surveillance Network, November 1963

Division of Radiological Health, Public Health Service

The Radiation Surveillance Network (RSN) is made up of 73 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State health department personnel.

Air

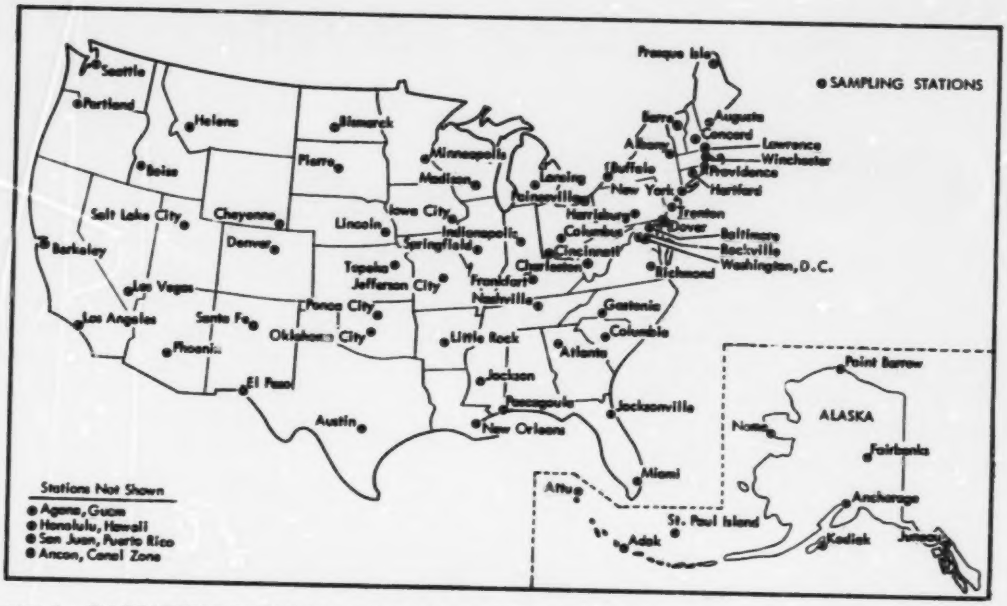
Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower. Field estimates of the gross beta activity of airborne particulates are derived by comparing portable survey meter readings of these filters with readings taken from a Sr^{90}–Y^{90} standard. This determination is usually made about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. Until January 24, 1964, the Network's station operators reported their field estimates daily to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. Effective on that date, regular reporting of field estimates by telephone was discontinued but provision was made for continued telephone reporting of any values greater than 10 pc/m^3 (or 5 pc/m^3 in Alaska, Hawaii or Puerto Rico).

The filters are then forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for a more refined measurement using a thin-window, gas-flow proportional counter, calibrated with a 38,700 pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and is re-counted 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula: $AT^{1.2} = C$ (*1*).[2] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

---

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 through August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] In this expression, A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at T=1.



● SAMPLING STATIONS
Seattle
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Springfield
Topeka
Jefferson City
Frankfort
Las Vegas
Ponca City
Nashville
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Austin
Pascagoula
New Orleans
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
Lansing
Painesville
New York
Hartford
Harrisburg
Trenton
Columbus
Dover
Baltimore
Cincinnati
Rockville
Charleston
Washington, D.C.
Richmond
Gastonia
Columbia
Atlanta
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, NOVEMBER 1963

The November 1963 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN data are presented with Canadian air data in the form of isogram lines in figure 5.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta concentration of precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m², C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \text{x } 1000$$

The November 1963 average concentrations and total depositions are given in table 2.

Profiles

The profiles of the monthly average fission product beta activity of airborne particulates for each RSN station covering the period of time from the formation of the network in 1956 to the end of 1960 were published in the July 1961 issue of *Radiological Health Data*. In recent issues, several profiles have been updated each month. The last column of table 1 gives the issue of Radiological Health Data having the most recent profile for each station. Eight profiles are updated in figure 2.

107

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, NOVEMBER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average[a]	Last profile in *RHD*
Alaska:	Adak	30	1.5	<0.10	0.50	Nov. 1963
	Anchorage	28	2.1	0.20	0.95	Jul. 1963
	Attu	29	1.7	<0.10	0.72	Dec. 1963
	Fairbanks	16	0.57	0.22	0.32	Aug. 1963
	Juneau	23	1.0	<0.10	0.39	Sep. 1963
	Kodiak	21	1.7	0.25	0.71	Oct. 1963
	Nome	20	1.7	0.16	0.69	Feb. 1964
	Point Barrow	23	0.71	<0.10	0.39	Jan. 1964
	St. Paul Island	26	1.7	0.15	0.78	Mar. 1964
Ariz:	Phoenix	24	3.5	0.64	1.4	Sep. 1963
Ark:	Little Rock	27	2.0	0.68	1.4	Sep. 1963
Calif:	Berkley	19	1.4	0.38	0.75	Oct. 1963
	Los Angeles	17	2.9	0.44	1.5	Feb. 1964
Canal Z:	Ancon	12	0.62	<0.10	<0.19	b
Colo:	Denver	27	2.7	0.49	1.3	Nov. 1963
Conn:	Hartford	25	1.6	<0.10	0.82	Oct. 1963
Del:	Dover	13	2.2	0.44	1.1	Aug. 1963
D. C:	Washington	30	3.1	<0.10	1.1	Mar. 1963
Fla:	Jacksonville	26	2.2	0.21	1.3	Oct. 1963
	Miami	30	2.8	0.16	1.4	Feb. 1964
Ga:	Atlanta	25	6.6	0.77	2.0	Jul. 1963
Guam:	Agana	30	0.9	<0.10	0.37	Mar. 1963
Hawaii:	Honolulu	25	1.5	0.21	0.72	Feb. 1964
Idaho:	Boise	27	2.4	<0.10	0.88	Dec. 1963
Ill:	Springfield	26	1.3	0.14	0.81	Mar. 1964
Ind:	Indianapolis	23	1.9	0.15	1.0	Jul. 1963
Iowa:	Iowa City	28	1.6	0.32	0.88	Jan. 1964
Kans:	Topeka	24	1.9	0.53	1.2	Jul. 1963
Ky:	Frankfort	26	2.2	0.23	0.98	Feb. 1964
La:	New Orleans	24	2.6	0.53	1.2	Mar. 1964
Maine:	Augusta	30	1.7	<0.10	0.71	Mar. 1964
	Presque Isle	28	1.0	<0.10	0.43	Nov. 1963
Md:	Baltimore	19	2.6	<0.10	1.1	Nov. 1963
	Rockville	15	3.2	<0.10	1.4	Mar. 1964
Mass:	Lawrence	29	1.7	<0.10	0.83	Aug. 1963
	Winchester	24	1.3	<0.10	0.65	b
Mich:	Lansing	30	2.2	0.15	1.1	Feb. 1964
Minn:	Minneapolis	22	1.4	0.21	0.80	Mar. 1964
Miss:	Jackson	28	2.5	0.53	1.3	Mar. 1963
	Pascagoula	8	2.1	0.59	1.6	Dec. 1963
Mo:	Jefferson City	25	1.6	0.33	1.0	Nov. 1963
Mont:	Helena	23	2.3	0.61	1.2	Nov. 1963
Neb:	Lincoln	1	0.57	0.57	0.57	Apr. 1963
Nev:	Las Vegas	23	5.1	0.82	2.4	Jul. 1963
N.H:	Concord	17	1.8	0.11	1.0	Feb. 1964
N.J:	Trenton	29	2.0	<0.10	0.98	Apr. 1964
N.Mex:	Santa Fe	21	5.6	0.66	1.6	Dec. 1963
N.Y:	Albany	17	2.0	<0.10	0.94	Jul. 1963
	Buffalo	18	2.5	<0.10	0.85	Nov. 1963
	New York	12	1.6	0.14	0.84	Dec. 1963
N.C:	Gastonia	25	1.8	<0.10	1.1	Jan. 1964
N.Dak:	Bismarck	24	2.0	0.34	0.91	Feb. 1964
Ohio:	Cincinnati	18	1.5	<0.10	0.90	Aug. 1963
	Columbus	27	2.1	<0.10	1.0	Feb. 1963
	Painesville	28	3.2	0.20	1.3	Oct. 1963
Okla:	Oklahoma City	24	1.4	0.28	1.0	Apr. 1963
	Ponca City	23	1.1	0.33	0.69	Oct. 1963
Ore:	Portland	27	3.1	0.40	1.3	Oct. 1963
Pa:	Harrisburg	21	2.6	<0.10	0.86	Jan. 1964
P.R:	San Juan	23	0.8	0.14	0.39	Mar. 1964
R.I:	Providence	25	1.9	<0.10	0.96	Jan. 1964
S.C:	Columbia	24	1.5	0.16	0.97	Dec. 1963
S.Dak:	Pierre	29	1.8	0.36	0.97	Sep. 1963
Tenn:	Nashville	30	3.2	0.25	1.3	Jan. 1964
Tex:	Austin	25	2.3	0.75	1.4	Aug. 1963
	El Paso	29	2.5	0.55	1.3	Jan. 1964
Utah:	Salt Lake City	30	2.6	0.41	1.2	Aug. 1963
Vt:	Barre	27	2.2	<0.10	0.87	Sep. 1963
Va:	Richmond	27	1.7	<0.10	0.84	Sep. 1963
Wash:	Seattle	29	1.0	<0.10	0.48	Jul. 1963
W.Va:	Charleston	28	2.0	0.13	0.96	Dec. 1963
Wisc:	Madison	26	1.4	0.14	0.85	Sep. 1963
Wyo:	Cheyenne	26	2.8	0.52	1.2	Aug. 1963
Network summary		1738	6.6	<0.10	0.98	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

[b] Initial profile scheduled for a future issue.

TABLE 2.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, NOVEMBER 1963

Station location		Average concentration[a] (pc/liter)	Total deposition[a] (nc/m²)
Alaska:	Anchorage	280	0.5
	Fairbanks	1,200	17
	Juneau	450	71
Ark:	Little Rock	350	52
Calif:	Berkeley	230	18
	Los Angeles	200	14
Colo:	Denver	<200	<3
Conn:	Hartford	220	19
D.C:	Washington	310	41
Fla:	Jacksonville	<200	<13
	Miami	350	22
Ga:	Atlanta	b	b
Idaho:	Boise	b	b
Ill:	Springfield	380	8
Ind:	Indianapolis	420	28
Iowa:	Iowa City	460	20
Kans:	Topeka	630	15
Ky:	Frankfort	670	20
La:	New Orleans	<200	<53
Maine:	Augusta	320	93
	Presque Isle	540	11
Md:	Baltimore	460	183
Mass:	Lawrence	450	100
	Winchester	480	47
Mich:	Lansing	440	24
Minn:	Minneapolis	350	5
Miss:	Jackson	<200	<117
Mo:	Jefferson City	320	13
Mont:	Helena	8,000	18
Nebr:	Lincoln	b	b
Nev:	Las Vegas	b	b
N.J:	Trenton	280	8
N. Mex:	Santa Fe	500	7
N.Y:	Albany	240	21
	Buffalo	b	b
N.C:	Gastonia	<200	<19
N. Dak:	Bismarck	b	b
Ohio:	Columbus	1,000	13
	Painesville	370	41
Okla:	Oklahoma City	b	b
	Ponca City	300	15
Ore:	Portland	270	32
Pa:	Harrisburg	280	22
P.R:	San Juan	<200	<18
R.I:	Providence	380	27
S.C:	Columbia	280	39
S. Dak:	Pierre	b	b
Tenn:	Nashville	550	29
Tex:	Austin	680	2
	El Paso	1,000	14
Utah:	Salt Lake City	230	9
Vt:	Barre	490	41
Va:	Richmond	220	29
Wash:	Seattle	300	48
W. Va:	Charleston	370	27
Wisc:	Madison	340	18
Wyo:	Cheyenne	b	b

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by D = <0.2 P in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition if the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] No evaporated sample received.

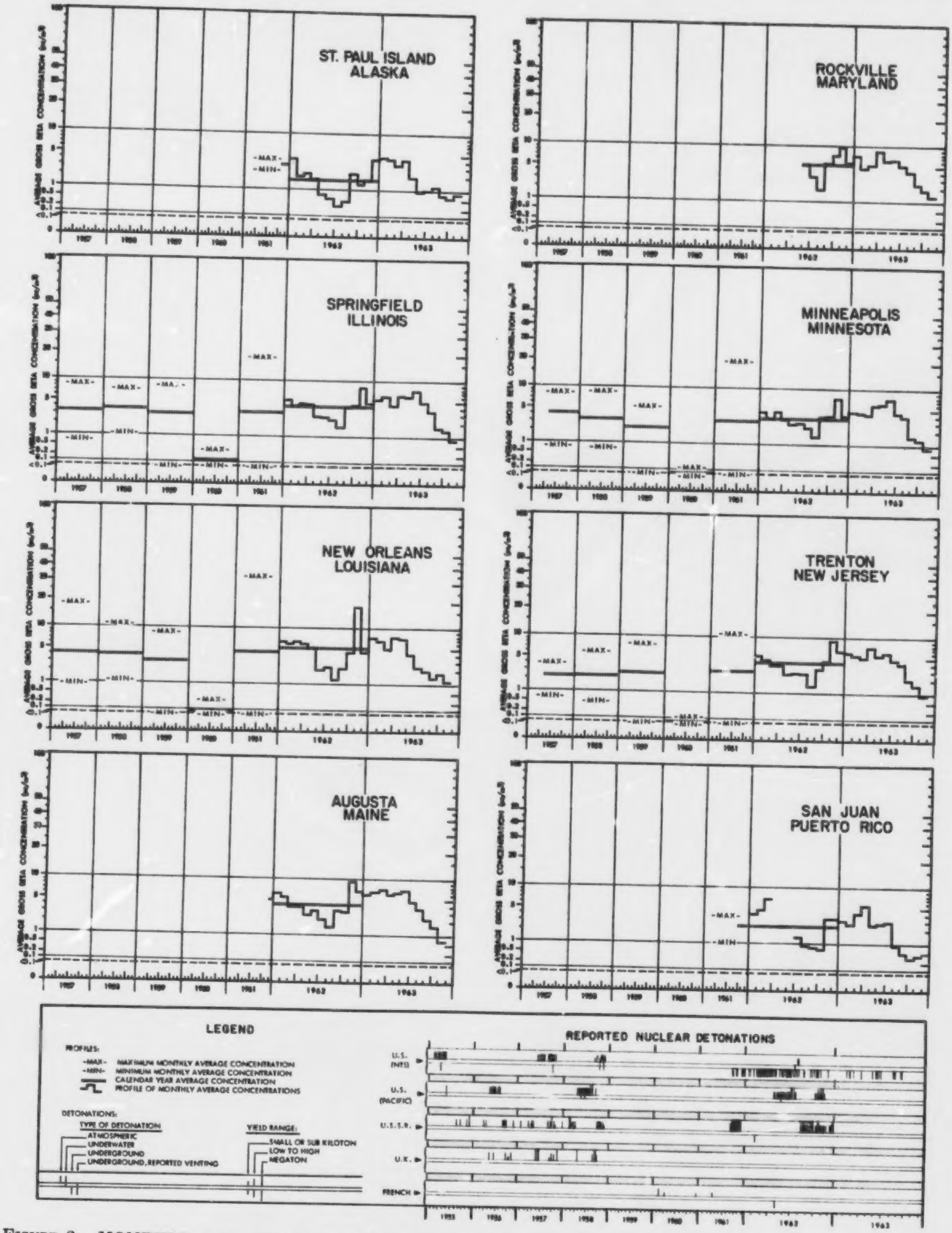


FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957—NOVEMBER 1963

2. Canadian Air Monitoring Program,[3] November 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare *(3–7)*.

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for November 1963 are given in table 3 and presented in conjunction with U. S. and Mexico data by an isogram map (figure 5).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radio-nuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The

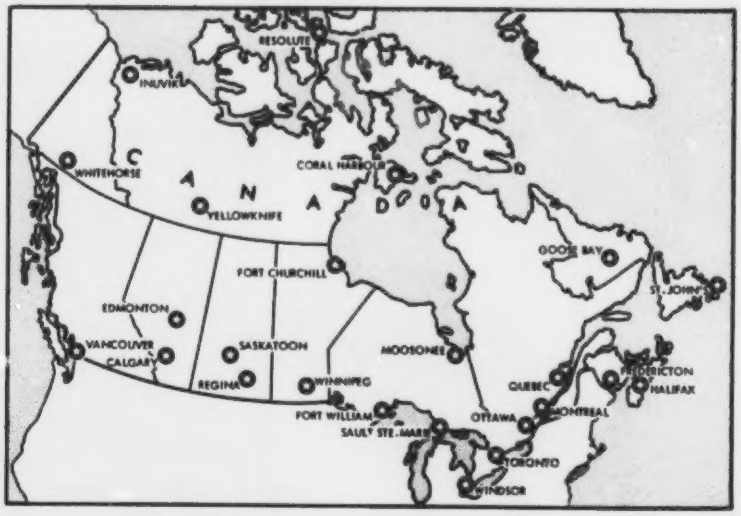


FIGURE 3.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, NOVEMBER 1963

---

[3] Data from *Radiation Protection Programs, Vol. 1, No. 12:* 11–24, Radiation Protection Division, Canadian Department of National Health and Welfare, (December 1963).

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, CANADA, NOVEMBER 1963

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	27	3.0	0.3	1.0
Coral Harbour	23	2.0	0.1	0.5
Edmonton	29	1.4	0.4	0.7
Ft. Churchill	30	1.6	0.1	0.6
Ft. William	29	1.7	0.0	0.9
Fredericton	29	1.4	0.0	0.5
Goose Bay	27	1.3	0.0	0.6
Halifax	28	2.1	0.1	0.9
Inuvik	30	1.4	0.3	0.7
Montreal	30	1.8	0.1	0.7
Moosonee	30	2.1	0.0	0.6
Ottawa	24	2.0	0.1	0.8
Quebec	29	1.7	0.1	0.6
Regina	30	4.8	0.3	1.0
Resolute	30	1.0	0.0	0.5
St. John's, Nfld	29	2.3	0.1	0.8
Saskatoon	[illegible]	3.5	0.4	1.0
Sault Ste. Marie	29	1.9	0.0	0.9
Toronto	30	1.0	0.0	0.4
Vancouver	30	1.8	0.1	0.7
Whitehorse	30	1.8	0.2	0.7
Windsor	30	2.6	0.1	1.2
Winnipeg	30	1.9	0.3	0.9
Yellowknife	29	1.1	0.1	0.6
Network summary	692	4.8	0.0	0.7

filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}-Y^{90} source. Gross beta activities for November samples are given in table 4. Radionuclide analyses appear quarterly.

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, NOVEMBER 1963

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	761	10.0
Coral Harbour	547	8.2
Edmonton	298	6.7
Ft. Churchill	426	22.7
Ft. William	758	27.7
Fredericton	246	44.4
Goose Bay	268	20.9
Halifax	371	58.5
Inuvik	276	5.3
Montreal	394	58.7
Moosonee	329	27.4
Ottawa	259	42.9
Quebec	395	55.9
Regina	1453	8.1
Resolute	234	18.4
St. John's, Nfld	271	36.4
Saskatoon	325	10.2
Sault Ste. Marie	385	39.4
Toronto	409	24.6
Vancouver	322	52.5
Whitehorse	211	5.4
Windsor	809	29.0
Winnipeg	390	12.5
Yellowknife	197	7.0
Average	431	26.4

3. Mexican Air Monitoring Program, November 1963

National Commission of Nuclear Energy Mexico

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network is made up of 17 stations (see figure 4), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institutio de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

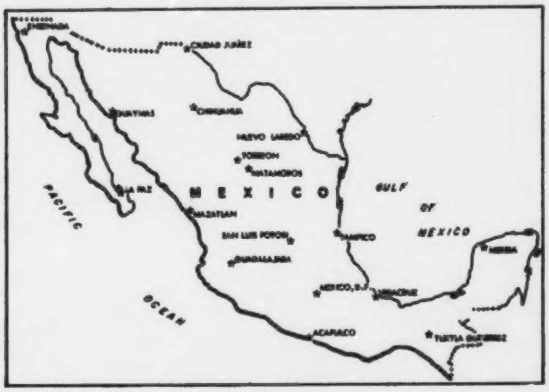


FIGURE 4.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or more days a week, at the rate of approximately 1,200 cubic meters

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, NOVEMBER 1963

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	8	1.3	0.3	0.8
Ciudad Juárez	23	2.2	0.2	1.1
Chihuahua	23	2.9	0.5	1.2
Ensenada	8	2.3	0.5	0.9
Guadalajara[a]	3	0.5	0.1	—
Guaymas	3	3.5	0.9	—
La Paz	14	2.6	0.9	1.4
Matamoras	7	1.0	0.5	0.8
Mazátlan[a]	1	1.5	—	—
Mérida	14	2.1	0.4	1.0
México, D.F.[b]	18	2.1	0.1	0.6
Nuevo Laredo[a]	4	1.3	0.7	—
San Luis Potosí	7	1.3	0.1	0.6
Tampico	12	1.9	0.6	1.1
Torreón	15	2.7	0.7	1.3
Tuxtla Gutiérrez[a]	0	—	—	—
Veracruz[a]	3	0.6	0.3	—

[a] Sampling equipment was out of order for all or most of the month, therefore, the average is not given.
[b] Mexico City.

per day, through a 6 x 8 inch high-efficiency glass fiber filter using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminacion Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during November 1963 are presented in table 5. The data are also represented after adjustment for intercalibration in the beta activity isogram map of North America, figure 5.

4. Pan American Air Sampling Program, November 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas to develop their own radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, NOVEMBER 1963

[Concentrations in pc/m³]

Sampling stations	Number of samples	Maximum	Minimum	Average[a]
Caracas, Venezuela	21	0.50	<0.10	0.18
Lima, Peru	14	0.23	<0.10	0.13
Santiago, Chile	16	0.20	<0.10	0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

The three air sampling stations included in the program are operated by the technical staff of the ministry of health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The November 1963 air monitoring results from the three participating countries are given in table 6. The Caracas station is shown on the gross beta concentration isogram map (figure 4). The November average at this station, adjusted by the RSN intercalibration factor is <0.14 pc/m³, which is considerably below the lowest isogram lined used on the map (1 pc/m³).[4]

5. Gross Beta Activity in Air, North America, November 1963

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[5] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Air Monitoring Program, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Air Monitoring Program (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

---

[4] The RSN factor is 1.28 (see page 112).

[5] The January to October 1963 Isogram Maps were published in the May 1963 through February 1964 *Radiological Health Data.*

Figure 5 shows the November 1963 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and the Mexican Air Monitoring Program. An intercalibration factor of 1.28 was applied to the RSN data and 0.81 to the Mexican data thereby using Canadian data as a frame of reference.

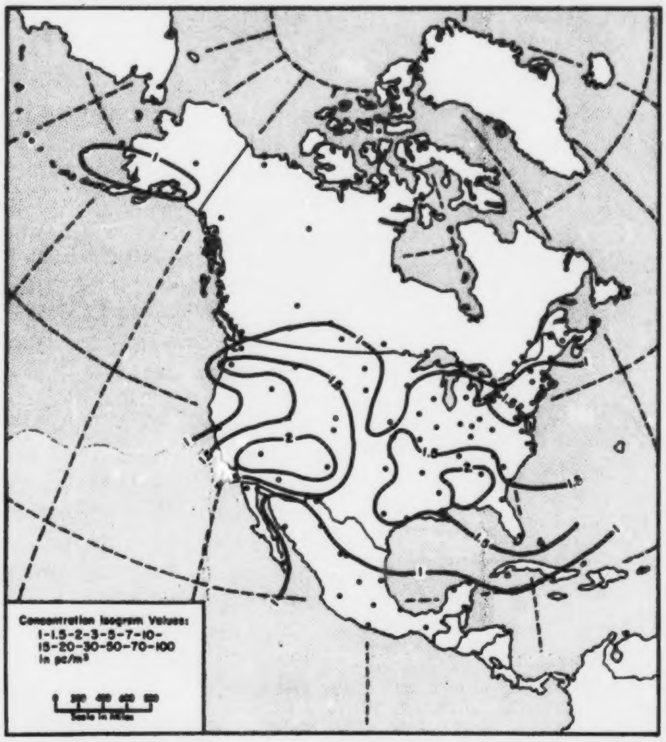


FIGURE 5.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, NOVEMBER 1963

REFERENCES

(*1*) Way, K., and E. P. Wigner: The Rate of Decay of Fission Products, *Physical Review, 73:* 1318–30 (June 1, 1948).

(*2*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D. C. 20201 (Distribution by official request).

(*3*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW–RP–3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) Bird, P. M., A. H. Booth, and P. G. Mar: *Annual Report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4*, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) Mar, P. G.: *Annual Report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5*, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) Beale, J. and Gordon: *The Operation of the Radiation Protection Division Air Monitoring Program, RPD–11*, Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*7*) Booth, A. H.: *The Calculation of Maximum Permissible Levels of Fallout in Air and Water and Their Use in Assessing the Significance of 1961 Levels in Canada, RDP–21*, Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*8*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(*9*) Lockhart, L. B. Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963), summarized in *Radiological Health Data*, January 1964.

FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, OCTOBER 1963

Health and Safety Laboratory, Atomic Energy Commission

Total gamma activity measurements for weekly ground-level air filter samples taken at 80th Meridian stations (see figure 1) during October 1963 are listed in table 1, together with monthly average concentrations and the fractions of the total gamma activity in excess of 1 Mev. The monthly average total gamma concentrations are plotted in figure 2, as an activity-latitude profile and compared with the third quarter average profile. Details of sampling procedures and analytical methodology have previously been given by Collins (*1, 2*).

The October results in general show no major changes in ground level air activity concentrations in either the Northern or the Southern Hemisphere to results obtained for September 1963. The October average for the northern sites was 0.93 photons per minute per cubic meter (γ/min/m^3) with a range of from 0.12 to 1.9 γ/min/m^3. At stations in the South-

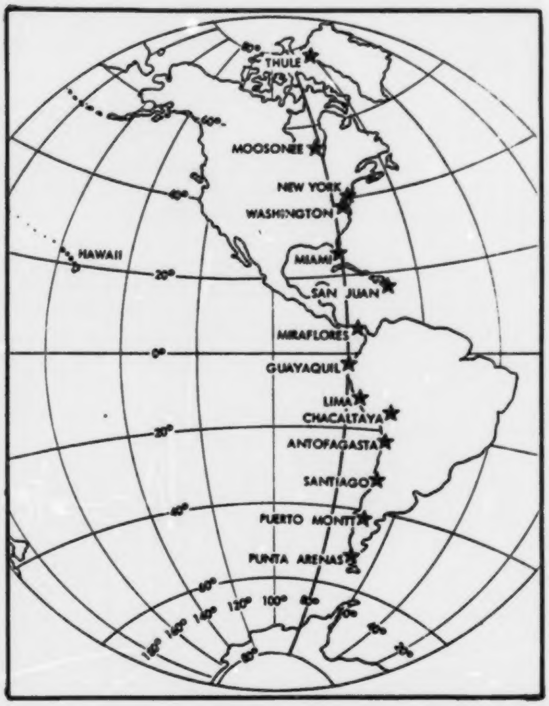


FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, OCTOBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m^3)		Gamma ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$
		Filter	Average for month	
Thule	10/1–8	0.453		0.042
	10/8–15	0.814		0.042
	10/15–22	1.07		0.041
	10/22–11/1	0.917	0.814	0.041
Moosonee	10/1–8	0.834		0.048
	10/8–15	1.15		0.040
	10/15–22	0.865		0.038
	10/22–11/1	0.996	0.961	0.039
New York	10/1–8	0.216		0.049
	10/8–15	1.33		0.049
	10/15–22	0.339	1.28	0.044
Washington	10/1–8	1.71		0.038
	10/8–15	1.42		0.049
	10/15–22	1.73		0.048
	10/22–11/1	1.35	1.55	0.047
Miami	10/1–8	2.42		0.049
	10/8–15	1.93		0.048
	10/15–22	1.48		0.049
	10/22–11/1	1.69	1.88	0.045
Mauna Loa	10/1–8	0.406		0.046
	10/8–15	0.864		0.048
	10/15–22	0.531		0.045
	10/22–11/1	0.496	0.574	0.043
San Juan	10/1–8	0.157		0.051
	10/8–15	0.192		0.052
	10/15–22	0.516		0.038
	10/22–11/1	0.248	0.278	0.044
Miraflores	10/1–8	0.134		0.055
	10/8–15	0.0424		0.071
	10/15–22	0.0710		0.067
	10/22–11/1	0.240	0.122	0.048
Guayaquil	10/1–8	0.123		0.046
	10/8–15	0.0561		0.072
	10/15–22	0.153		0.045
	10/22–11/1	0.0724	0.101	0.051
Lima	10/1–8	0.154		0.054
	10/8–15	0.140		0.043
	10/15–22	0.112		0.052
	10/22–11/1	0.168	0.144	0.042
Chacaltaya	10/1–8	0.113		0.043
	10/8–15	0.0691		0.061
	10/15–22	0.0818		0.026
	10/22–11/1	0.0855	0.0874	0.051
Antofagasta	10/1–8	0.139		0.051
	10/8–15	0.0836		0.054
	10/15–22	0.120		0.041
	10/22–11–1	0.0917	0.109	0.051
Santiago	10/1–8	0.0962		0.055
	10/8–15	0.0602		0.063
	10/15–22	0.0780		0.053
	10/22–11/1	0.0790	0.0784	0.055
Puerto Montt	10/1–8	0.0284		0.010
	10/8–15	0.0233		0.023
	10/15–22	0.0251		0.041
	10/22–11/1	0.0465	0.0308	0.044
Punta Arenas	10/8–15	0.0455		0.028
	10/15–22	0.0191		0.035
	10/22–11/1	0.0187	0.0278	0.052

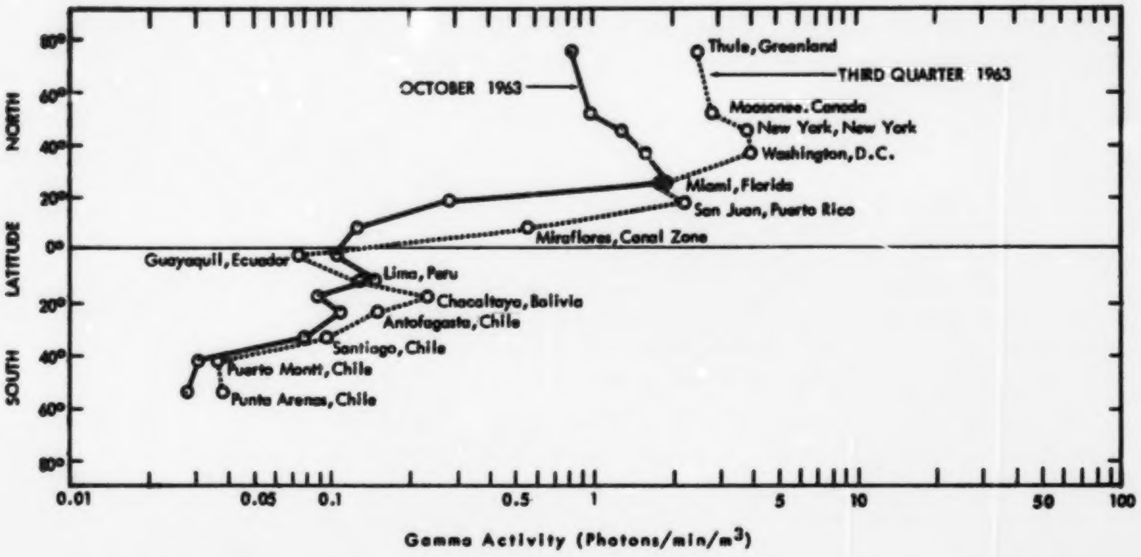


FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, THIRD QUARTER AND NOVEMBER 1963

ern Hemisphere the average concentration was 0.083 with a range of from 0.028 to 0.14 γ/min/m^3.

Total beta activity estimates have not been given for samples taken since June 1963 because of the continued appearance of larger concentrations of high energy gamma emitters than would be expected in old fission product mixtures. According to observations reported for thermally-irradiated U^{235} (*1*) only about 1 percent of the total gamma activity in the October samples would be expected to be in excess of 1 Mev. The actual values average 4.7 percent and 4.6 percent for the Northern and Southern Hemispheres respectively. Continued radiochemical and gamma spectrometric analyses are in process to determine to what extent enrichment in high-energy activation products such as Y^{88} and Sb^{124} and fission products such as Ce^{144} and Ru^{106} is responsible for these discrepancies.

REFERENCES

(*1*) Collins, W. R., Jr: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, January 1963, *Radiological Health Data*, 4:342–6, (July 1963).

(*2*) Collins, W. R., Jr: Fission Product Gamma Activity in Airborne Particulates, The 80th Meridian Network, March and April 1963, *Radiological Health Data* 4:437–40, (September 1963).

Section II.—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, November 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activitation of a pasturized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Complete analytical results are available 6 to 7 weeks after collection; publication in *Radiological Health Data* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine–131, cesium–137 and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, a two-week composite is analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error[a] (pc/liter)	Estimated concentration (pc/liter)	Error[a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	± 10%
Barium-140	0 to 100	±10	100 or greater	± 10%
Cesium-137	0 to 100	±10	100 or greater	± 10%
Strontium-89	0 to 50	± 5	50 or greater	± 10%
Strontium-90	0 to 20	± 2	20 or greater	± 10%

[a] Two standard deviations.

Calcium analyses at SERHL are done by an ion exchange and volumetric method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum.

Data Presentation

Table 2 presents summaries of the analyses for November 1963 (October 27–November 30, 1963). Although not shown in table 2, the iodine-131 and barium-140 monthly average concentrations in milk were <10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero has been used as the best approximation to a nondetectable concentration of iodine-131 or barium-140. A similar procedure is used for the network average.

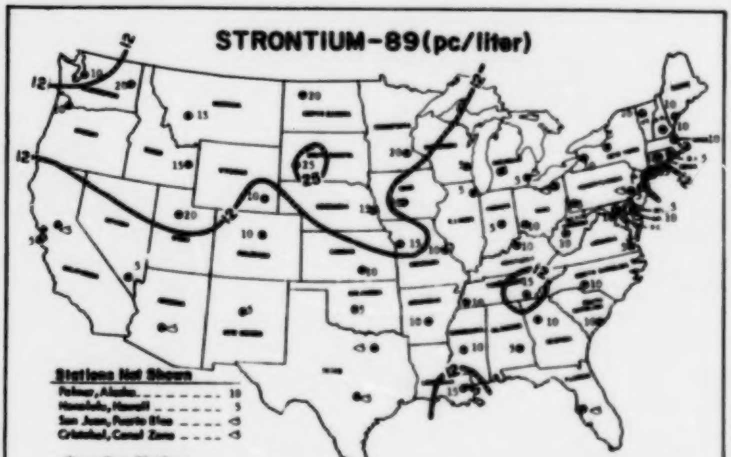


FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK

---

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

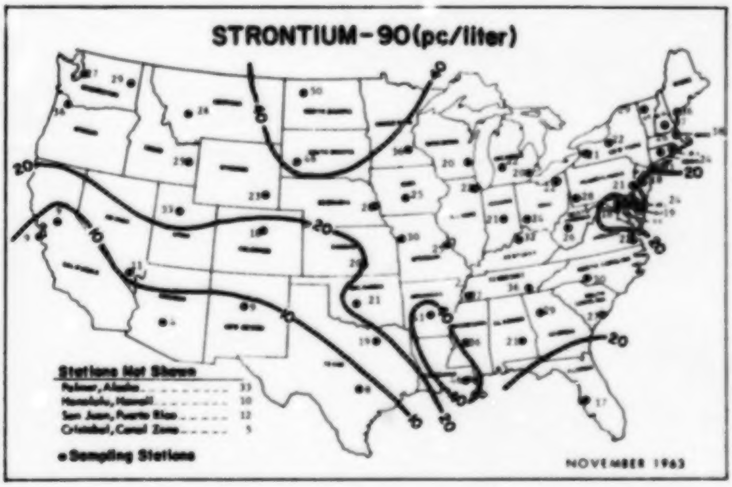

STRONTIUM-90(pc/liter)
20
30
Stations Not Shown
Palmer, Alaska 33
Honolulu, Hawaii 10
San Juan, Puerto Rico 12
Cristobal, Canal Zone 5
• Sampling Stations
NOVEMBER 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

Figures 1, 2, and 3 are isoconcentration maps showing the estimated strontium-89, strontium-90, and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isoconcentration maps were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isoconcentration contours are made according to available information on milksheds. In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly average data shown in table 2.

Continuing the practice followed in previous issues of *RHD* the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

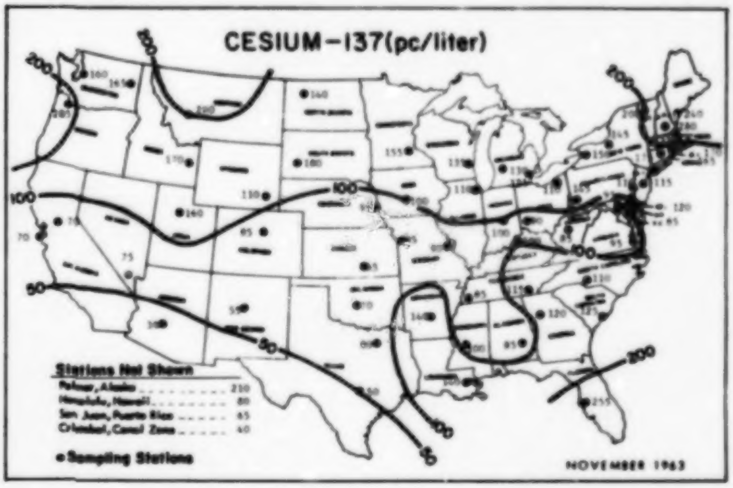

CESIUM-137(pc/liter)
200
100
50
Stations Not Shown
Palmer, Alaska 210
Honolulu, Hawaii 80
San Juan, Puerto Rico 65
Cristobal, Canal Zone 40
• Sampling Stations
NOVEMBER 1963

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, NOVEMBER 1963[a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr⁹⁰ graph in *RHD*
		Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	Third quarter	Avg. for month	
Ala:	Montgomery	1.17	1.22	1.4	1.5	45	5	21	21	85	85	Feb. 64
Alaska:	Palmer	1.17	1.25	1.5	1.6	45	10	24	33	160	210	Mar. 64
Ariz:	Phoenix	1.14	1.20	1.7	1.8	5	<5	3	4	25	30	Jan. 64
Ark:	Little Rock	1.19	1.20	1.3	1.5	105	10	44	41	170	140	Mar. 64
Calif:	Sacramento	1.18	1.24	1.6	1.6	10	<5	9	9	50	70	Dec. 63
	San Francisco	1.17	1.18	1.6	1.6	20	5	9	9	65	70	Feb. 64
C. Z:	Cristobal		1.15		1.5		<5		5		40	b
Colo:	Denver	1.18	1.22	1.6	1.6	40	10	22	18	110	85	Dec. 63
Conn:	Hartford	1.16	1.21	1.6	1.7	40	10	31	24	215	165	Dec. 63
Del:	Wilmington	1.18	1.23	1.6	1.6	35	5	30	24	150	120	Jan. 64
D. C:	Washington	1.13	1.17	1.5	1.5	45	10	21	18	110	85	Feb. 64
Fla:	Tampa	1.19	1.23	1.4	1.4	25	<5	14	17	275	255	Jan. 64
Ga:	Atlanta	1.18	1.18	1.4	1.5	75	10	33	29	190	120	Feb. 64
Hawaii:	Honolulu	1.18	1.18	1.6	1.7	15	5	12	10	85	80	Mar. 64
Idaho:	Idaho Falls	1.17	1.19	1.5	1.6	60	15	33	25	160	170	Jan. 64
Ill:	Chicago	1.21	1.19	1.6	1.7	30	5	23	22	125	110	Feb. 64
Ind:	Indianapolis	1.19	1.25	1.6	1.6	40	5	24	21	110	100	Dec. 63
Iowa:	Des Moines	1.18	1.22	1.5	1.5	50	10	28	25	85	100	Jan. 64
Kans:	Wichita	1.16	1.14	1.5	1.6	35	10	24	20	80	65	Mar. 64
Ky:	Louisville	1.14	1.16	1.4	1.5	100	10	39	32	125	100	Jan. 64
La:	New Orleans	1.21	1.23	1.4	1.5	80	15	41	46	160	140	Mar. 64
Maine:	Portland	1.18	1.23	1.6	1.7	55	10	38	36	300	240	Jan. 64
Md:	Baltimore	1.14	1.11	1.4	1.5	60	10	25	19	145	95	Jan. 64
Mass:	Boston	1.18	1.25	1.6	1.7	70	10	47	38	320	255	Feb. 64
Mich:	Detroit	1.17	1.21	1.6	1.6	30	5	22	20	130	125	Dec. 63
	Grand Rapids	1.18	1.23	1.6	1.6	35	5	22	22	145	130	Jan. 64
Minn:	Minneapolis	1.17	1.16	1.5	1.7	70	20	34	36	170	155	Feb. 64
Miss:	Jackson	1.22	1.28	1.4	1.4	80	10	36	36	125	100	Dec. 63
Mo:	Kansas City	1.15	1.21	1.6	1.5	55	15	29	30	75	85	Dec. 63
	St. Louis	1.16	1.23	1.5	1.6	45	10	25	25	85	90	Mar. 64
Mont:	Helena	1.16	1.23	1.4	1.5	80	15	39	26	245	200	Mar. 64
Nebr:	Omaha	1.17	1.24	1.6	1.5	50	15	29	28	100	95	Jan. 64
Nev:	Las Vegas	1.16	1.04	1.6	1.7	20	[illegible]	12	11	90	75	Feb. 64
N. H:	Manchester	1.20	1.22	1.6	1.7	60	10	43	37	355	280	Jan. 64
N. J:	Trenton	1.15	1.22	1.6	1.7	30	5	26	18	160	115	Dec. 63
N. Mex:	Albuquerque	1.12	1.14	1.6	1.5	20	5	12	9	50	55	Mar. 64
N. Y:	Buffalo	1.16	1.18	1.7	1.7	40	10	26	21	170	150	Dec. 63
	New York	1.14	1.21	1.6	1.7	60	15	41	31	225	175	Feb. 64
	Syracuse	1.19	1.20	1.6	1.7	45	5	31	22	165	145	Mar. 64
N. C:	Charlotte	1.17	1.19	1.4	1.5	80	10	35	30	155	110	Mar. 64
N. Dak:	Minot	1.16	1.19	1.5	1.6	130	20	60	50	170	140	Jan. 64
Ohio:	Cincinnati	1.20	1.25	1.6	1.6	40	10	28	24	95	90	Dec. 63
	Cleveland	1.16	1.22	1.6	1.7	40	<5	24	22	125	110	Mar. 64
Okla:	Oklahoma City	1.13	1.16	1.4	1.5	55	5	22	21	90	70	Feb. 64
Ore:	Portland	1.22	1.26	1.4	1.7	50	20	33	36	190	205	Dec. 63
Pa:	Philadelphia	1.15	1.22	1.6	1.6	35	<5	26	21	140	110	Mar. 64
	Pittsburgh	1.20	1.25	1.5	1.6	60	5	36	28	190	145	Mar. 64
P. R:	San Juan	1.14	1.17	1.4	1.6	35	<5	14	12	95	65	Mar. 64
R. I:	Providence	1.19	1.20	1.7	1.6	45	5	35	26	225	170	Jan. 64
S. C:	Charleston	1.17	1.24	1.4	1.5	60	10	26	27	150	125	Dec. 63
S. Dak:	Rapid City	1.07	1.27	1.5	1.8	100	25	49	46	175	180	Feb. 64
Tenn:	Chattanooga	1.20	1.24	1.4	1.5	110	15	46	36	185	115	Feb. 64
	Memphis	1.18	1.23	1.4	1.5	75	10	33	27	100	85	Jan. 64
Tex:	Austin	1.14	1.16	1.5	1.6	20	<5	10	8	55	50	Feb. 64
	Dallas	1.16	1.20	1.5	1.5	40	<5	19	19	75	80	Dec. 63
Utah:	Salt Lake City	1.13	1.17	1.5	1.6	55	20	30	33	205	160	Mar. 64
Vt:	Burlington	1.16	1.22	1.6	1.6	55	10	39	29	245	200	Dec. 63
Va:	Norfolk	1.15	1.18	1.4	1.6	45	5	23	22	115	95	Dec. 63
Wash:	Seattle	1.20	1.24	1.5	1.6	55	10	36	27	205	160	Feb. 64
	Spokane	1.22	1.25	1.5	1.6	55	20	30	29	160	165	Dec. 63
W. Va:	Charleston	1.13	1.15	1.4	1.5	85	10	34	26	120	85	Feb. 64
Wis:	Milwaukee	1.24	1.29	1.8	1.8	30	5	21	20	130	135	Jan. 64
Wyo:	Laramie	1.15	1.19	1.5	1.6	45	10	27	23	125	110	Jan. 64
Network average		1.17	1.21	1.5	1.6	52	9	28.4	24.8	147	125	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

[b] Station began operation in October 1963.

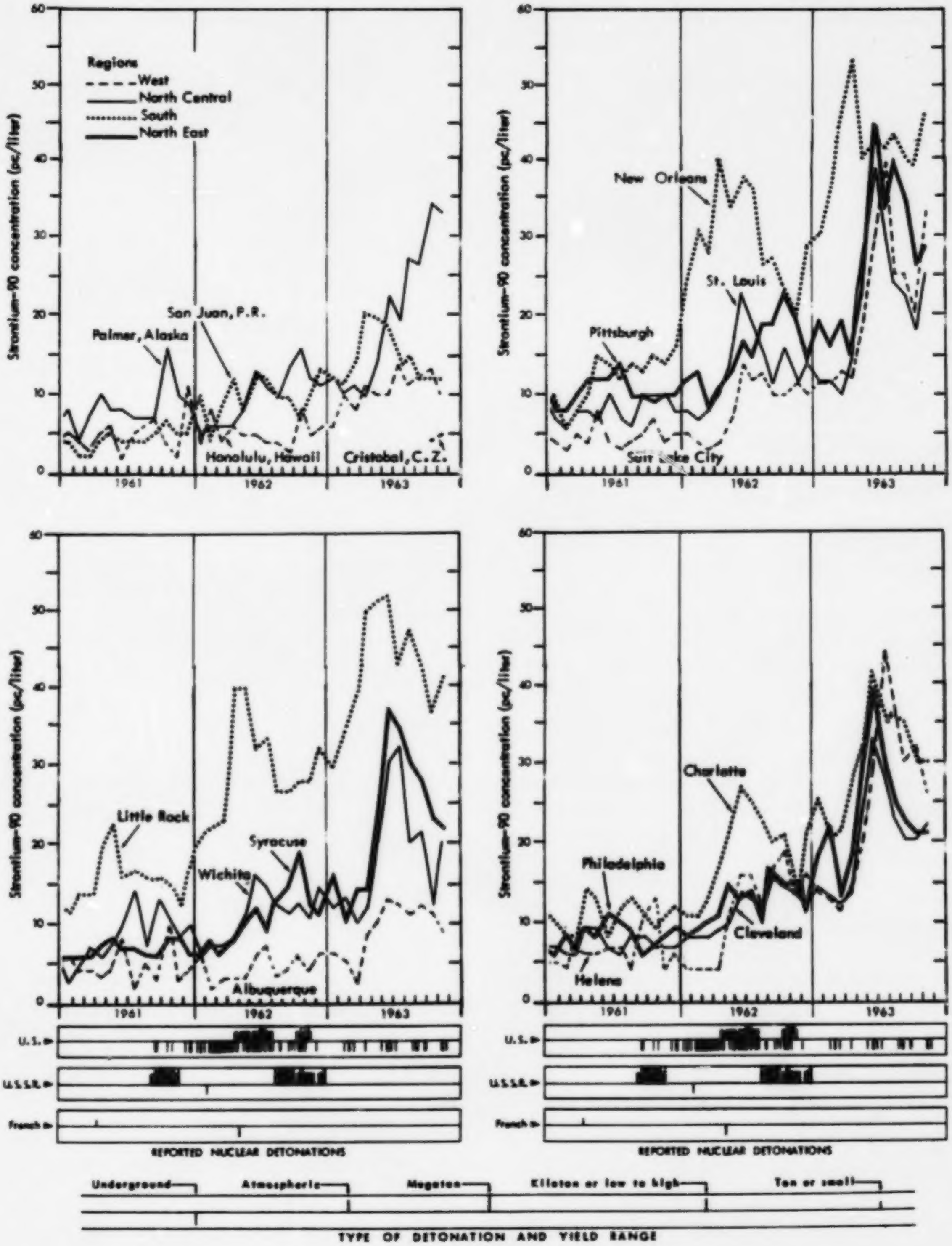


FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, NOVEMBER 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5-5	26	<1-4	1	<10	63	<5-45	2	<10	63
10	24	5-9	5			50-95	21		
15	7	10-14	3			100-145	23		
20	5	15-19	6			150-195	9		
25	1	20-24	17			200-245	5		
		25-29	14			250-295	3		
		30-34	6						
		35-39	7						
		40-50	4						

2. California Milk Network,[2] July-September 1963

State of California, Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendicino milksheds to the program in March 1962, sampling of milk weekly or biweekly has been conducted at 10 major milksheds (see figure 5). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

Radiostrontium is separated chemically and counted in a low background counter, usually for a 60-minute period. Potassium-40, iodine-131, cesium-137, and barium-140 in fluid milk are determined by gamma scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium-40 concentration (pc/liter) by 1.18 x 10^{-3}.

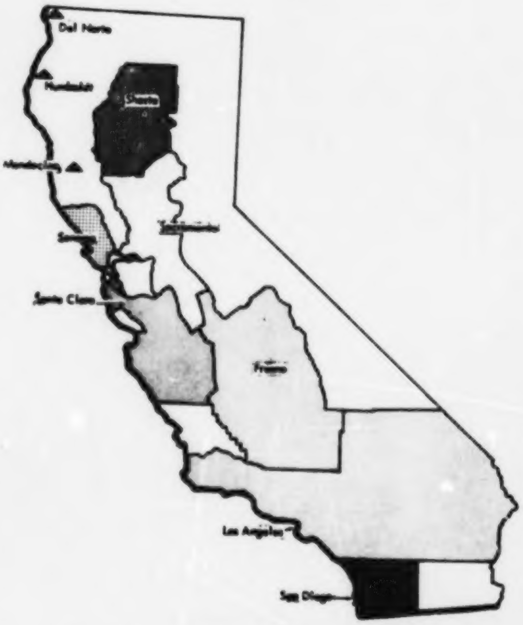


FIGURE 5.—CALIFORNIA MILKSHEDS

Results

The monthly averages of the radionuclide and calcium data for milk for the period July-September 1963 are presented in table 4. A summary of the 1961-1963 results by Heslep and Cornish appears in the December 1963 *Radiological Health Data* (*2*).

---

[2] Data from *Radiological Health News, Vol. 3, No. 1*, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

TABLE 4.—RADIONUCLIDES IN CALIFORNIA MILK, JULY-SEPTEMBER 1963[a]

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
July	1.31	1.18	1.27	1.09	1.21	1.14	1.13	1.14	1.16	1.18	1.18
August	1.25	1.16	1.21	1.10	1.20	1.15	1.14	1.12	1.14	1.16	1.16
September	1.29	1.13	1.40	1.12	1.20	1.20	1.12	1.20	1.23	1.23	1.21
Potassium-40											
July	1195	1260	1158	1301	1295	1249	1255	1294	1311	1267	1249
August	1170	1265	1094	1315	1285	1204	1280	1204	1208	1232	1226
September	1145	1257	1136	1235	1300	1220	1244	1293	1274	1280	1238
Strontium-89											
July	141	18	33	11	22	22	8	24	40	26	35
August	108	10	19	7	19	10	3	19	21	21	24
September	43	6	11	5	10	6	3	7	14	11	12
Strontium-90											
July	57.4	7.6	12.8	4.1	8.4	8.3	4.0	8.6	17.0	11.0	13.9
August	43.6	6.1	14.1	6.2	9.3	7.2	4.4	8.1	11.5	9.5	12.0
September	45.8	5.1	12.3	5.6	9.9	8.3	3.5	5.4	14.0	10.3	12.0
Cesium-137											
July	179	72	56	45	38	57	38	86	92	70	73
August	140	53	79	47	52	40	27	87	69	54	65
September	131	53	60	50	33	43	27	55	71	59	58

[a] The monthly iodine-131 and barium-140 averages at all stations during this period were zero.

Note: All values reported are the best available estimate. If the counting rate of the sample is not equal to at least twice the 95-percent error, a "b" would be printed beside the value.

3. Florida Milk Network, November 1962-December 1963

Division of Radiological and Occupational Health, Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the sampling of milk from five areas shown in figure 6. Radiostrontium and cesium–137 analyses are also conducted but results are not available for publication. A Regional State Board of Health Laboratory is located in each of these areas. Milk samples are sent first to the regional laboratories where the samples are passed through ion exchange columns. The column resins are removed and sent to the State Radiological Health Laboratory in Orlando for analysis.

Milk produced in the counties comprising each area is generally processed, marketed and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms using locally-grown feed in the "West Florida" region to larger farms using different types of grass and predominantly purchased feeds in the southern areas.

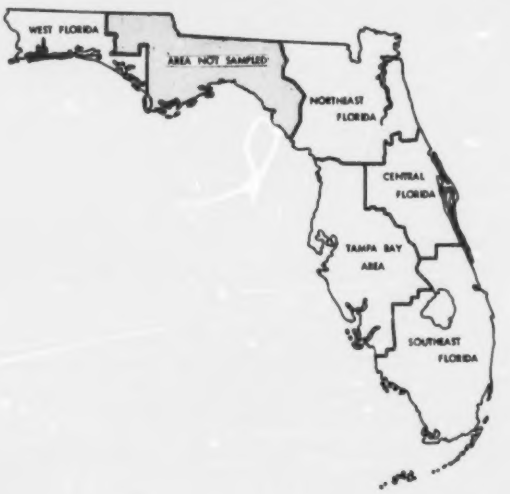


FIGURE 6.—FLORIDA MILK SAMPLING LOCATIONS

Sampling

Raw milk samples are taken from a tank truck, the route of which passes by farms which are widely dispersed over the area represented. Where there is no route representative of a large portion of the area, samples are collected directly from selected farms and composited. Samples were collected weekly when iodine–131 was detectable in milk. Presently the sampling is on a monthly basis.

Analytical Procedures

Iodine–131 analyses are performed by using an ion exchange technique. From November 1962 through July 1963, one-gallon samples were run through 80 ml of resin and counted with a 2" x 2" sodium iodide crystal and single channel analyzer. Sensitivity was increased in August and September 1963 by use of a 4" x 4" crystal and multi-channel analyzer. Improvements in analytical methods instituted in October 1963 have permitted the same sensitivity to be obtained using only one-liter samples. These samples are passed through 15 ml of resin. The resin is then mounted in a 3" x 3" well crystal connected to a single channel analyzer.

The monthly averages of iodine–131 concentrations in milk produced in Florida are shown in table 5.

TABLE 5.—IODINE-131 IN FLORIDA RAW MILK

[Average concentrations in pc/liter]

Month	Sampling location				
	West Florida	N. E. Florida	Central Florida	Tampa Bay Area	S. E. Florida
Nov. 62	147	53	[a]	—	—
Dec. 62	93	69	—	—	—
Jan. 63	65	52	—	—	—
Feb. 63	14	9	11	—	—
Mar. 63	3	<2	<2	—	—
Apr. 63	<2	<2	<2	—	—
May 63	<2	<2	<2	—	—
June 63	<2	<2	<2	—	—
July 63	<2	<2	<2	<2	<2
Aug. 63	<2	<2	<2	<2	<2
Sep. 63	<2	<2	<2	<2	<2
Oct. 63	<2	<2	<2	<2	<2
Nov. 63	<2	<2	<2	<2	<2
Dec. 63	<2	<2	<2	<2	<2

[a] A dash indicates sampling not begun.

4. Indiana Milk Network,
November 1963

Bureau of Environmental Sanitation,
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling section (see figure 7).

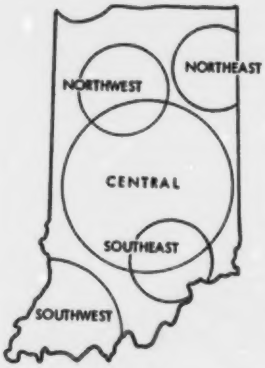


FIGURE 7.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-half-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*3*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 6. The State average is an arithmetic average of the station values.

TABLE 6.—RADIONUCLIDES IN INDIANA MILK, NOVEMBER 1963

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	I^{131}	Cs^{137}	Ba^{140}
Northeast	15	15	<10	120	<10
Southeast	15	19	<10	110	<10
Central	5	23	<10	95	<10
Southwest	15	16	<10	80	<10
Northwest	20	15	<10	115	<10
State average	14	18	<10	104	<10

5. Pennsylvania Milk Network, September 1962-November 1963

Bureau of Environmental Health, Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (see figure 8). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies, which supply the area and are composited in proportion to the amount of milk processed by each dairy. This composite sample is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg for analysis. Iodine-131 analyses were carried out from September 1962 through January 1963 when concentrations fell to nondetectable levels. Analysis for strontium-90 is carried out on all samples. The strontium-90 program was initiated on a statewide basis in April 1963.

The chemical separation technique used for strontium-90 is essentially an ion exchange method described by Porter, *et al.* (3) One liter of milk is passed through an ion exchange column. Yttrium-90 is eluted from the resin and is counted in an automatic low background proportional counter with a window thickness of 0.8 mg/cm^2. Iodine was also separated by passing one liter of milk through an ion exchange column (4). Iodine-131 counting was performed with 2″ x 2″ sodium iodide gamma scintillation crystal and multichannel analyzer.

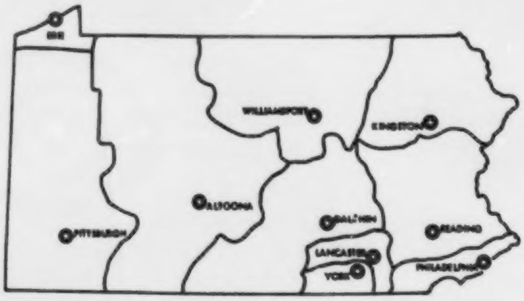


FIGURE 8.—PENNSYLVANIA MILK SAMPLING STATIONS AND MILK CONSUMPTION AREAS

The monthly average strontium-90 levels in pasteurized milk are shown in table 7 and the monthly average iodine-131 results are shown in table 8.

TABLE 8.—IODINE-131 IN PENNSYLVANIA MILK, SEPTEMBER 1962-JANUARY 1963

[Concentrations in pc/liter]

Sampling location	September	October	November	December	January
Dauphin	40	80	80	20	<10
Erie	80	110	60	20	<10
Kingston	40	90	95	35	<10
Lancaster	20	50	45	35	<10
Pittsburgh	60	110	200	30	<10
Reading	30	60	70	20	<10
Williamsport	40	70	55	25	<10
York	20	70	40	10	<10
State average	41.2	80	80.6	24.4	<10

TABLE 7.—STRONTIUM-90 IN PENNSYLVANIA MILK, APRIL-NOVEMBER 1963

[Concentrations in pc/liter]

Sampling location	April	May	June	July	August	September	October	November
Altoona	12	[a]	18	50	41	38	33	8
Dauphin	7	16	33	29	35	25	22	18
Erie	25	20	40	42	41	29	34	20
Kingston	15	10	25	42	48	36	30	25
Lancaster	7	24	22	22	28	38	25	13
Philadelphia	21	28	29	22	31	31	25	—
Pittsburgh	15	20	26	44	54	22	20	12
Reading	12	21	22	36	43	27	21	14
Williamsport	9	14	18	36	41	49	24	11
York	12	24	18	32	24	20	20	12
State Average	13.5	19.7	25.1	35.5	38.6	31.5	25.4	14.7

[a] No sample.

6. Canadian Milk Network,[3]
November 1963

Radiation Protection Division,
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 9) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, strontium–89, cesium–137, and stable potassium and calcium.

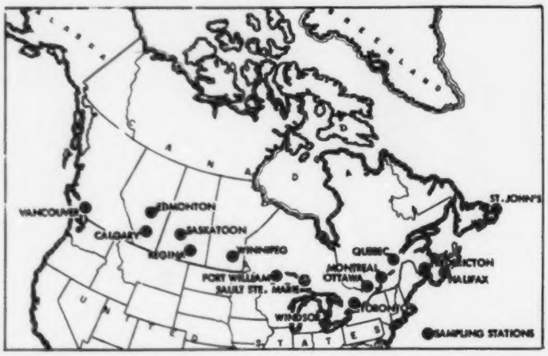


FIGURE 9.—CANADIAN MILK SAMPLING STATIONS

Analytical Methods

For the analysis of iodine–131, radiochemical methods are used (*5*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodine ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine–131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to one-liter sample of milk, and the milk is then evaporated under infra-red lamps in a tray lined with a polyethylene sheet. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium is separated by burning nitric acid precipitations. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium–90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectrometry using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. Stable potassium content is estimated from the potassium–40 concentrations.

---

[3] Data from *Radiation Protection Programs, Vol. 1, No. 12*: 25–30, Radiation Protection Division, Canadian Department of National Health and Welfare. (December 1963)

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the "carrier." In the determination of cesium this factor is not involved.

The operational error must be combined with the counting error, which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, were previously published (*6*). For example, the 2σ total errors (representing 95 percent confidence) associated with a measured concentration of 10 pc/liter, in units of pc/liter are Sr^{89}, 2.5; Sr^{90}, 1.5; I^{131}, 5; and Cs^{137}, 6.

Results

Table 9 presents monthly averages of strontium-89, strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 indicate that all samples had <5 pc/liter. Figure 10 shows the variation of the network average radionuclide concentrations of Canadian whole milk.

TABLE 9.—RADIONUCLIDES IN CANADIAN WHOLE MILK, NOVEMBER 1963

(Radionuclide concentrations in pc/liter)

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89	Strontium-90	Cesium-137
Calgary	1.05	1.5	24	50.4	298
Edmonton	1.25	1.4	14	33.6	194
Ft. William	1.29	1.4	17	57.5	251
Fredericton	1.25	1.4	20	56.5	338
Halifax	1.26	1.5	14	43.0	271
Montreal	1.26	1.5	17	38.6	231
Ottawa	1.26	1.5	15	29.3	192
Quebec	1.23	1.6	20	55.5	328
Regina	1.19	1.5	25	51.5	174
St. John's Nfld.	1.25	1.3	15	51.2	230
Saskatoon	1.25	1.3	21	46.7	172
Sault Ste. Marie	1.21	1.5	22	41.3	219
Toronto	1.26	1.5	7	19.5	127
Vancouver	1.38	1.4	23	44.5	378
Windsor	1.22	1.5	6	17.2	81
Winnipeg	1.34	1.4	22	41.0	209
Average	1.25	1.4	17	42.3	230

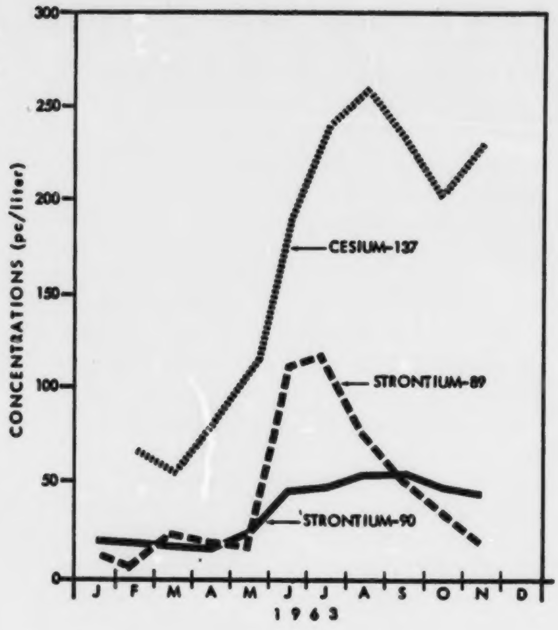


FIGURE 10.—NETWORK AVERAGE STRONTIUM-89, STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

REFERENCES

(*1*) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957–April 1963, *Radiological Health Data*, *4*: 511–23, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (October 1963).

(*2*) Heslep, J. M. and A. C. Cornish: California Milk Network and Milkshed Comparisons, April–June 1963, *Radiological Health Data*, *4*: 596–9, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (December 1963).

(*3*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry 33*: 1306–8 (September 1961).

(*4*) Boni, A. L.: *Personal Communication*, Savannah River Plant, E. I. duPont de Nemours and Company.

(*5*) DasGupta, A. K., and H. G. Green: A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(*6*) Public Health Service: Canadian Milk Network, *Radiological Health Data 4*: 561–3, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (November 1963).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER 1962-NOVEMBER 1963

Division of Radiological Health,
Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to assess the contribution of milk to an individual's or a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). However, the FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*). The ICRP has set the maximum permissible concentration (MPC) for cesium–137 in water for the population at large equal to 2000 pc/liter (*7*). This MPC may be applied to milk, if it is assumed that all food would be contaminated to the same extent.

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data, 5*: 57 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data 4*: 15–17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data, 4*: 124–7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, 3: ii–iii (September 1962).

(*7*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

---

[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK [a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		November 1962–October 1963	December 1962–November 1963	November 1962–October 1963	December 1962–November 1963	November 1962–October 1963	December 1962–November 1963	November 1962–October 1963	December 1962–November 1963
Ala:	Montgomery	67	64	20	20	14	9	68	72
Alaska:	Palmer	37	33	17	19	11	8	95	108
Ariz:	Phoenix	15	14	4	4	8	6	20	22
Ark:	Little Rock	135	125	40	41	32	24	138	143
Calif:	Sacramento	42	39	9	9	9	7	51	55
	San Francisco	75	73	12	13	9	8	61	65
Colo:	Denver	27	26	15	16	8	7	78	81
Conn:	Hartford	26	23	20	21	9	5	125	133
Del:	Wilmington	36	30	23	24	19	8	111	115
D. C:	Washington	43	40	19	19	13	7	87	89
Fla:	Tampa	36	33	13	14	17	11	196	206
Ga:	Atlanta	93	89	27	28	20	14	126	131
Hawaii:	Honolulu	37	36	10	10	11	9	66	69
Idaho:	Idaho Falls	45	43	20	22	11	7	112	121
Ill:	Chicago	24	21	18	19	10	6	92	96
Ind:	Indianapolis	35	31	21	21	16	9	84	88
Iowa:	Des Moines	66	60	22	23	22	12	78	82
Kans:	Wichita	48	44	17	18	19	12	67	69
Ky:	Louisville	101	91	30	31	20	9	93	97
La:	New Orleans	147	141	38	40	24	19	136	142
Maine:	Portland	31	26	27	28	11	5	169	179
Md:	Baltimore	51	48	20	20	13	7	107	109
Mass:	Boston	36	32	30	31	8	5	180	192
Mich:	Detroit	21	17	19	19	12	6	96	101
	Grand Rapids	22	19	18	19	11	7	99	104
Minn:	Minneapolis	53	49	26	27	13	7	130	135
Miss:	Jackson	147	139	32	34	23	17	98	102
Mo:	Kansas City	80	73	24	25	27	16	71	74
	St. Louis	54	50	20	21	14	8	74	77
Mont:	Helena	51	48	24	25	19	14	139	149
Nebr:	Omaha	56	51	23	24	23	16	85	89
Nev:	Las Vegas	19	19	7	8	6	5	59	61
N. H:	Manchester	33	29	28	30	9	6	202	215
N. J:	Trenton	26	22	20	20	13	6	103	107
N. Mex:	Albuquerque	24	23	8	9	10	8	36	39
N. Y:	Buffalo	24	22	20	21	6	5	116	121
	New York	34	30	25	27	12	6	127	135
	Syracuse	27	25	21	22	8	5	107	113
N. C:	Charlotte	72	67	29	30	8	6	104	108
N. Dak:	Minot	85	81	42	44	10	5	118	123
Ohio:	Cincinnati	45	39	24	24	21	10	76	79
	Cleveland	29	25	19	20	14	7	91	95
Okla:	Oklahoma City	75	69	22	22	29	21	80	82
Ore:	Portland	98	83	26	27	15	9	131	143
Pa:	Philadelphia	33	28	22	22	17	7	105	108
	Pittsburgh	41	36	26	26	22	9	125	130
P. R:	San Juan	[c] 87	79	[c] 14	14	[c] 15	14	[c] 89	87
R. I:	Providence	31	26	24	25	12	6	135	142
S. C:	Charleston	73	69	25	26	16	13	108	114
S. Dak:	Rapid City	70	67	30	33	16	9	121	131
Tenn:	Chattanooga	118	110	33	35	17	10	122	127
	Memphis	103	96	29	30	22	14	78	81
Tex:	Austin	39	36	9	9	30	24	42	45
	Dallas	90	85	20	20	45	38	74	77
Utah:	Salt Lake City	36	34	19	20	10	8	127	135
Vt:	Burlington	31	27	24	25	10	4	140	149
Va:	Norfolk	51	47	21	22	12	7	92	94
Wash:	Seattle	71	59	23	24	15	8	135	141
	Spokane	53	50	23	24	10	7	117	125
W. Va:	Charleston	72	66	28	28	11	6	87	89
Wis:	Milwaukee	24	20	16	17	14	6	94	99
Wyo:	Laramie	43	40	19	20	5	5	109	113
Network average		55	50	24.8	22.7	15	10	103	108

[a] Annual averages were computed on basis of 52 weekly averages.
[b] Annual averages were computed on basis of 53 weekly averages.
[c] Average is for 48 weeks (No sample was received in November 1962).

128

THE ANALYTICAL QUALITY CONTROL SERVICE OF THE DIVISION OF RADIOLOGICAL HEALTH—INTERLABORATORY STUDY OF IODINE-131 SURVEILLANCE MEASUREMENTS IN MILK

Marvin Rosenstein and Abraham S. Goldin[1]

Ever since the Division of Radiological Health (DRH) began to measure levels of radioactivity in environmental samples, quality control of these measurements has been emphasized. Since October 1962, the quality control program has been placed on a more formal basis, under the designation of Analytical Quality Control Service, DRH. In this report the objectives and operations of this program are reviewed, along with the fundamental means of meeting these objectives. Included also as an example of the functioning of the program is a summary of the fields of investigation and the data from the first quality control study on iodine–131 in milk.

Structure of the Analytical Quality Control Service (AQCS)

The Analytical Quality Control Service consists of three general activities: intralaboratory quality control, interlaboratory quality control, and outside assistance. *Intra*laboratory quality control has as its objective the maintenance of precision in analyses, and is basically the responsibility of the individual DRH laboratories. The AQCS serves, however, as a general coordinating group in establishing criteria for the intralaboratory programs. *Inter*laboratory quality control establishes the overall validity of results originating from the several DRH laboratories and endeavors to assist in improving analytical conditions that are not acceptable. Outside assistance is provided to State and local radiological health laboratories and DRH contract laboratories.

Objectives and Mechanics of AQCS

The objectives of AQCS are threefold. First, it maintains a continuous collection of representative radiological data for statistical analysis as described below. Second, it determines the accuracy of these data. Third, it recommends steps to correct laboratory operations that do not meet the required limits of accuracy.

Collection of Data—Continuous collection of data is maintained through the distribution of appropriate environmental samples and the performance of technical experiments. The unknown environmental samples are analyzed by a round-robin procedure to measure the agreement among several laboratories. The technical experiments involve the analysis of (1) accurately known preparations (to obtain bias of results from a true value), and (2) blank preparations (to study the sensitivity of techniques and contamination of the laboratory). Each of these types of analysis has a different relationship to the determination of whether or not data are satisfactory.

Determination of Accuracy—Accuracy is determined by comparing statistically the agreement between observed data and correct values with expected or standard limits of variability. Selection of the proper limits of variability is of fundamental importance. These limits are chosen to reflect both the requirements for analytical measurements and laboratory capabilities under normal operating conditions. Once these limits have been chosen, conventional statistical tests can be applied to obtain the desired information concerning the accuracy of the observed data.

Corrective Measures—When corrective measures are indicated by the analysis of the data, two steps are taken to assure that valid decisions are made. First, using knowledge of the related disciplines involved in the radiological measurements, along with the statistical indications of the data, factors that could contribute to the type of inaccuracy observed are listed and given further consideration and study. Second, suggestions as to the possible causes of unacceptable results are forwarded to the laboratory submitting the results as recommendations for implementing the im-

---

[1] Mr. Rosenstein is Program Coordinator and Dr. Goldin is Director of The Analytical Quality Control Service of the Division of Radiological Health, located at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

129

provement of the measurements. The laboratory, in turn, tests these recommendations and accepts those which prove to be valid. Subsequent samples are distributed until the process under study is brought under control. After this has been accomplished, periodic samples are issued to monitor laboratory operations.

Fields of Investigation

The AQCS is responsible for providing quality control measures for all types of environmental radiological measurements. At present, it is focusing most attention on the results of Pasteurized Milk Network samples. An extensive study is being made on all the elements for which milk analyses are designed. Approximately 15–20 percent of the analytical workload is devoted to internal or external quality control measures. Iodine–131 and strontium–90 have been given particular emphasis because of their biological importance. Projects are underway for the study of analyses of diet samples, bone samples, and other environmental samples performed on a large scale.

Assistance to outside agencies has begun with the formation of a calibration standards program. This service makes available to these agencies nuclide preparations sufficient for calibrating instrumentation for radiological determinations. Plans are also in progress for sample distribution and quality control analyses similar to the DRH interlaboratory program.

Iodine–131 Quality Control Study

Milk samples were analyzed for iodine–131 by gamma spectroscopy in the Division of Radiological Health Laboratories located in Las Vegas, Nevada; Montgomery, Alabama; and Winchester, Massachusetts. In addition to these which carry the bulk of the network analytical load, two other divisional laboratories which have gamma spectroscopy capabilities were included in the study. Five such laboratories were included in this study.

To evaluate the ability of these laboratories to obtain accurate results for this type of measurement, milk samples were prepared by adding a known amount of calibrated iodine–131 solution to a master milk sample free of this nuclide. Evaporated milk which had been stored for several weeks met this requirement. In addition to the known amount of iodine–131, the milk samples contained the usual, but unknown concentrations of other radionuclide contaminants (cesium–137 and potassium–40). Subsamples of this preparation were distributed to the laboratories for analysis in accordance with a pre-planned schedule based on the control chart analysis (*1*) which was used in analyzing the resulting data. The data returned were then examined for accuracy; i.e., their agreement with the known iodine–131 value. The limits allowed for the variation of the observed iodine–131 values from the known iodine–131 values were calculated from an assigned standard deviation, based on past experiences of the capabilities of iodine–131 surveillance measurements and on a judgment as to the requirements for accuracy in this determination.

Two samples were distributed three weeks apart. Each milk sample was analyzed at three different time intervals, yielding a high level, an intermediate level and a low level. Figure 1 illustrates graphically as well as numerically the results of this study at the three iodine–131 concentrations. The improvement in the second sample results over those of the first sample results and their agreement with the expected values is apparent in figure 1. This figure expresses only the measurement of bias of the reported data. Precision within individual laboratories was also studied but is not discussed in this report. The analytical variations which are the subject of this report included the entire analytical system, from sample receipt at the laboratory through final calculations. The samples were utilized to detect data that were analytically unacceptable. It should be noted, however, that the discrepancies uncovered were not biologically significant.

To clarify the notations on the figure, the following explanations are given:

1. Expected Values: This is the amount of iodine–131 added to the milk and present at the time of analysis. These values are 460, 115 and 29 pc/liter.
2. Upper and Lower Warning Levels: This is the level between which the results are

130

expected to fall, based on knowledge of the analytical capabilities of the technique and overall accuracy requirements. These particular warning levels were based on the selected overall variation for individual iodine-131 determinations of ±10 pc/liter for levels <100 pc/liter and ± 10 percent for levels > 100 pc/liter, at two standard deviations. Since each value given in figure 1 represents the mean of four determinations in each laboratory, the expected standard deviation of these means is obtained by dividing the standard deviation of individual determinations by the square root of four (the number of determinations from which the mean is calculated). Therefore, the mean values of the data have an expected overall variation of ± 5 pc/liter for levels ≤100 pc/liter and ± 5 percent for levels > 100 pc/liter, at two standard deviations. These are the numbers used to describe the warning levels in figure 1. Any values falling within these levels are considered acceptable. Any values falling outside these levels warrant inspection.

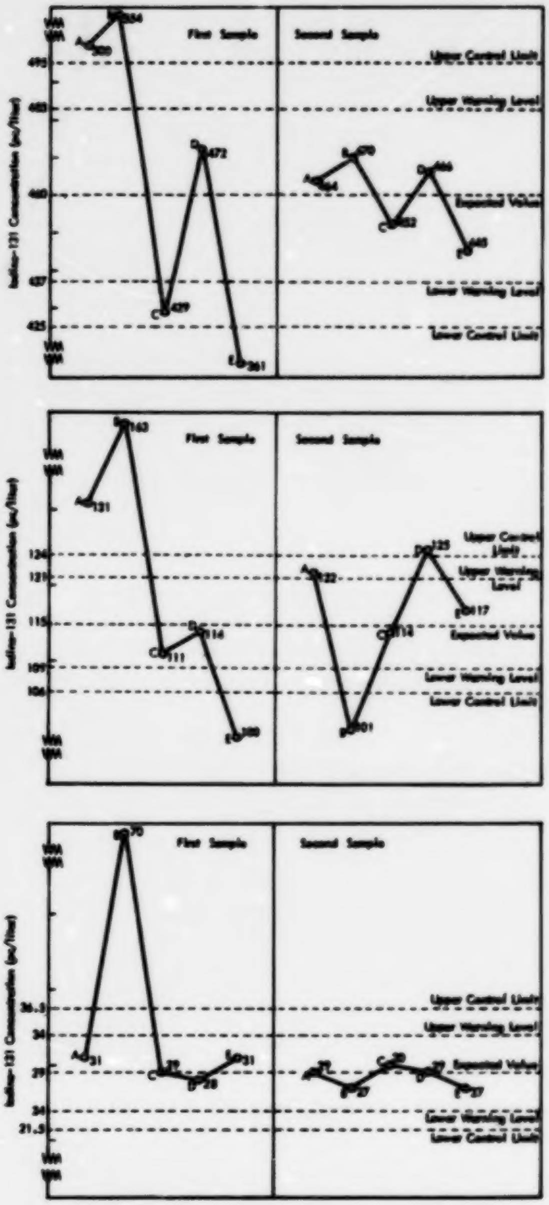


FIGURE 1.—IMPROVEMENT OF LABORATORY RESULTS OF IODINE-131 MEASUREMENTS IN MILK IN FIVE LABORATORIES (A, B, C, D, and E) FOR THREE CONCENTRATIONS OF ACTIVITY: 460, 115, and 29 pc/liter.

3. Upper and Lower Control Limits: These control limits were set at the ± three standard deviation limits, which are, for means of four determinations, ± 7.5 pc/liter for ≤ 100 pc/liter levels and ± 7.5 percent for >100 pc/liter levels. Any values falling outside these limits indicate that corrective measures are necessary.
4. A, B, C, D, E: These are the code names of the participating laboratories. Labortories A, C, and D are the Division laboratories which routinely analyze milk by gamma spectroscopy.

From figure 1, one can see that the results on the first sample are in general out of control. After detailed investigation of the data, from which recommendations were made to correct several discrepancies, a period of time was then allowed for corrective measures to be taken. A second sample was then issued and the same analysis repeated. In figure 1, the second sample results show a marked improvement in the quality of iodine-131 data. These latter results therefore indicated that individual iodine-131 analyses are being performed within an accuracy of ± 10 percent at the two standard deviation level.

Conclusions.

By the application of adequately designed samples, properly applied statistical methods, and appropriate corrective measures, the quality of radiological measurements can be maintained at an acceptable level. Thus, as in the case of the iodine–131 measurement study, once the analytical data appear to be under control, periodic checks can be made to continue surveillance and additional steps can be taken to improve the data even further.

The quality control procedure as applied to iodine–131 measurements in milk can be adapted to any other nuclides in environmental samples provided that a master sample can be produced containing a known amount of the nuclide of interest and an acceptable level of variability can be established. For example the technique is presently being applied by the Analytical Quality Control Service to strontium–90, cesium–137, radium–226, potassium, and calcium analyses in various environmental samples.

REFERENCE

(*1*) Duncan, Acheson J.: *Quality Control and Industrial Statistics*, Irwin 1959.

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, JULY-SEPTEMBER 1963

Division of Radiological Health, Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service (PHS) initiated its Institutional Diet Sampling Program in 1961. This program is administered by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program consisted of sampling diets in eight institutions, but it has since been expanded to 21 boarding schools or institutions, geographically distributed as shown in figure 1. Institutions selected range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (sampling point) except the one at Los Angeles is located in a community from which the PHS Pasteurized Milk Network collects samples. The analytical data from this program supplement the findings for the Institutional Diet Sampling Program.

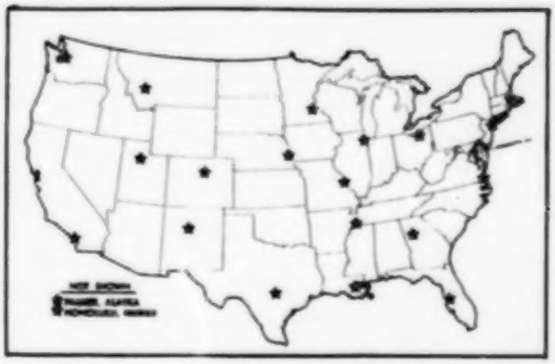


FIGURE 1.—INSTITUTIONAL DIET SAMPLING LOCATIONS

Sampling Procedure

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Each institution supplies one complete 7-day, 21-meal diet sample each month. Each day's sample is kept frozen during the collection period. After collection, the total sample is packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada, the Southeastern Radiological Health Laboratory, Montgomery, Alabama, or the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

Each sample is packaged in three parts: (1) solid and semisolid food minus those portions not ordinarily eaten; (2) liquid milk; (3) other beverages such as soft drinks, coffee and tea. A record of the contents of each meal and the approximate weight of each item is made by the institution's dietician and sent with the sample. Samples usually range from 6 to 16 liters in volume and weigh from 8 to 20 kilograms.

Analytical Procedures

Because calcium and phosphorous compounds may have an effect on the uptake of important bone-seeking radionuclides such as strontium–89 and strontium–90 (*2*), they are included in the analytical program. Total weight, stable calcium, and stable potassium determinations are obtained by conventional gravimetric or spectrophotometric methods. Phosphate determinations are made by a colorimetric technique.

The radioanalysis program is designed around three basic procedures: (1) gamma spectroscopy, (2) chemical separation of strontium–89 and strontium–90 with subsequent counting, and (3) total radium analysis. In the absence of interferences other than that from naturally-occurring radioactive potassium (K^{40}), minimum detectable concentrations for the gamma scan, expressed as pc/kg are: iodine–131, 10; cesium–137, 5; and barium–140, 10 pc/kg. Approximate minimum detectable concentrations for strontium–89, strontium–90, and total radium are: 5, 1, and 1 pc/kg, respectively. Since a constant weight of food is analyzed, the minimum detectable level on a per day basis (pc/day) will be dependent on the food intake.

Total radium is determined by ashing, separation, and coprecipitation of radium as sulfate or chromate. After samples are transferred to planchets and dried, alpha activity is measured by an internal proportional counter with an appropriate delay for checking ingrowth of radium daughters. Since naturally-occurring radionuclides may contribute to the reported total radium values, the total radium technique is a practical screening indicator only. The bone dose, calculated by assuming total radium to be only radium-226, would therefore be moderately high.

Data

Table 1 presents the dietary intake data expressed on a per-day basis from July 1963 through September 1963 for the 21 institutions from which samples were received. Also contained in the table is the range of ages of the children from which samples are being obtained. The reported radionuclide concentrations of these samples are extrapolated to the end of the sample collection period. The true iodine–131 intakes, therefore, may be somewhat greater than the reported values.

Certain of the radioanalyses are reported by the laboratories as being "less than" (<) a specified value. For data averaging, the method employed for presentation in table 1 is that all "less-than" data are assumed to be equal to the full "less-than" values as they appear in the column entitled "monthly maximum averages." The column entitled "monthly minimum averages" reflects the averages in which all "less-than" values are considered to be zero.

Figure 2 shows the overall average daily intake of radionuclides at all institutions since January 1961. The data are also presented graphically in figure 3, as a distribution of all sample values observed during the three months versus daily intake. The number of values reported during this quarter in each range is plotted as a frequency-distribution step chart.

133

Table 1.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE)

	Month (1963)	Alaska	California	Colorado	Florida	Georgia	Hawaii	Illinois	Louisiana	Massachusetts	Minnesota	Missouri
		Palmer	Los Angeles	Denver	Tampa	Atlanta	Honolulu	Chicago	New Orleans	Boston	Minneapolis	St. Louis
Age (years)		6–18	11–18	4–17	6–18	6–18	5–16	6–15	7–18	[a]	[b] <1–16	7–16
Total weight (kg/day)	July	1.21	—	2.48	1.94	1.43	1.87	1.79	2.12	1.45	1.56	—
	Aug	1.76	1.20	1.89	1.91	1.63	1.70	1.53	3.13	1.48	1.83	2.74
	Sept	1.33	—	2.47	2.91	1.81	1.26	1.88	2.42	1.66	1.56	2.51
Calcium (g/day)	July	0.5	—	1.5	1.1	0.5	0.6	1.2	1.3	0.9	0.7	—
	Aug	0.9	1.2	1.2	1.1	0.6	0.9	1.1	1.3	1.0	0.7	0.6
	Sept	0.6	—	1.5	1.1	0.6	0.6	1.3	1.0	1.2	0.6	1.6
Phosphorus as phosphate (g/day)	July	1.8	—	5.3	3.4	2.5	1.5	6.7	5.5	3.4	1.3	—
	Aug	3.1	3.3	3.3	4.9	3.7	4.2	3.7	8.0	3.3	3.1	2.5
	Sept	2.5	—	5.2	5.5	4.4	2.5	2.3	5.5	1.9	2.8	6.2
Potassium (g/day)	July	1.8	—	4.2	2.0	1.4	2.1	2.5	3.0	2.0	2.2	—
	Aug	2.8	1.6	1.9	2.9	2.0	2.6	2.7	5.0	2.2	3.1	4.7
	Sept	2.5	—	4.3	3.0	2.5	1.9	1.9	3.6	2.7	2.4	3.7
Total radium (pc/day)	July	<1	—	3.0	4.4	2.7	<1	<1	<3	<1	<1	—
	Aug	3.0	2.0	1.0	6.9	<3.9	<1	<1	4.2	<1	<1	1.0
	Sept	<1	—	<1	<3	<4.0	<1	<1	<4.4	1	<1	4.0
Strontium-89 (pc/day)	July	<5	—	<5	40	40	<5	50	130	5	15	—
	Aug	30	10	40	40	40	5	15	195	30	45	5
	Sept	10	—	40	45	50	5	25	185	45	35	40
Strontium-90 (pc/day)	July	14	—	79	15	8	17	100	34	18	26	—
	Aug	25	12	33	36	31	13	22	64	45	18	11
	Sept	17	—	16	32	25	7	26	48	43	18	57
Cesium-137 (pc/day)	July	90	—	210	280	95	85	145	180	225	125	—
	Aug	265	40	65	345	165	85	120	360	320	185	150
	Sept	105	—	135	470	165	65	185	230	315	135	150
Barium-140 (pc/day)	July	<10	—	<10	<20	<20	<10	<10	<30	<10	<10	—
	Aug	<10	<10	<10	<30	<30	<10	<10	<40	<10	<10	<10
	Sept	<10	—	<10	<30	<30	<10	<20	<30	<20	<10	<10
Iodine-131 (pc/day)	July	<10	—	<10	<20	<20	<10	<10	<30	<10	<10	—
	Aug	<10	<10	<10	<30	<30	<10	<10	<40	<10	<10	<10
	Sept	<10	—	<10	<30	<30	<10	<20	<30	<20	<10	<10

[a] Ages not available.
[b] Food samples not collected from children too young for solid diet.

The number of stations used in constructing these graphs was 18, 19, and 20 for the months of July, August, and September 1963, respectively. Therefore, the total number of samples represented in each chart is 57.

Discussion of Data

Total intake ranged between 0.90 and 3.13 kg/day during this quarter. The frequency-distribution step chart shows that 74 percent of the samples weighed between one and two kg/day.

The calcium intake ranged between 0.5 and 1.7 g/day, with fifty-six percent of the values being one g/day or less. Phosphate intake ranged from 1.3 to 8.0 g/day, with 84 percent of the values being less than 5 g/day. Ninety-three percent of the samples analyzed for potassium showed that the intake was between 1 and 4 g/day.

Total radium intake ranged between <1 and 6.9 pc/day with all but two samples having less than 5 pc/day.

Strontium–89 intake ranged between <5 and 195 pc/day. Twenty-one percent of the samples gave values between <5 and 20 pc/day. For purposes of comparison the Federal Radiation Council (FRC) range II for strontium–89 is 200 to 2000 pc/day (*3*). The maximum strontium–90 intake during this quarter was 100 pc/day. Again for comparison, 33 percent of the values were below 20 pc/day. The FRC range II for strontium–90 is 20 to 200 pc/day (*3, 4*).

Although the intake of cesium–137 ranged from 40 to 470 pc/day, the distribution shows a pronounced peak between 120 and 160 pc/day formed by 32 percent of the results.

Both barium–140 and iodine–131 were below the limits of detectability during this quarter.

TABLE 1.—INSTITUTIONAL DAILY DIETARY INTAKE (BASED ON A 7-DAY COMPOSITE SAMPLE) Continued—

	Month (1963)	Montana Helena	Nebraska Omaha	New Mexico Albuquerque	New York New York	Ohio Cleveland	Tennessee Memphis	Texas Austin	Utah Salt Lake City	Virginia Norfolk	Washington Seattle	Monthly minimum average	Monthly maximum average
Age (years)		6–17	6–18	5–15	8–15	6–15	8–18	6–18	12–18	10–18	6–16		
Total weight (kg/day)	July	1.14	2.05	0.90	1.60	1.73	1.78	2.25	—	1.99	2.44	1.76	1.76
	Aug	1.85	1.96	1.73	—	1.74	2.00	1.97	—	1.78	2.02	1.89	1.87
	Sept	1.13	1.35	1.89	1.57	1.86	1.65	2.10	1.87	1.72	1.79	1.84	1.84
Calcium (g/day)	July	0.5	1.2	1.3	0.6	1.2	1.2	1.7	—	0.9	1.3	1.0	1.0
	Aug	0.8	1.2	1.6	—	1.0	0.9	0.8	—	0.7	1.0	1.0	1.0
	Sept	0.9	0.7	1.1	0.6	1.2	0.9	0.8	1.2	0.6	0.7	0.9	0.9
Phosphorus as phosphate (g/day)	July	2.1	1.7	1.5	4.4	4.0	4.0	7.0	—	4.6	4.9	3.5	3.5
	Aug	3.6	3.9	4.0	—	7.5	4.6	4.9	—	4.0	4.5	4.2	4.2
	Sept	2.9	2.8	4.2	3.2	3.1	4.3	4.9	3.7	3.7	2.6	3.7	3.7
Potassium (g/day)	July	1.8	3.1	1.3	3.3	3.0	2.4	2.9	—	2.2	3.9	2.5	2.5
	Aug	3.3	3.1	2.9	—	3.0	3.4	2.8	—	2.4	3.4	2.9	2.9
	Sept	2.0	2.1	2.7	3.2	3.1	1.9	2.4	2.7	1.8	3.0	2.7	2.7
Total radium (pc/day)	July	<1	1.0	2.0	<1	1.0	<4	<3	—	<3	<1	4.1	5.2
	Aug	3.0	1.0	1.0	—	<1	3.1	<3.6	—	<2.5	<1	1.4	2.2
	Sept	<1	2.0	<1	1.0	1.0	<2.2	<5.1	<1	<4.0	<1	0.5	2.1
Strontium-89 (pc/day)	July	55	25	<5	30	20	125	70	—	55	40	39	40
	Aug	40	40	15	—	40	70	35	—	30	45	41	41
	Sept	20	20	5	5	15	45	30	30	45	15	32	36
Strontium-90 (pc/day)	July	16	33	10	27	29	26	29	—	25	32	30	30
	Aug	26	27	15	—	77	41	24	—	22	33	30	30
	Sept	18	2	13	28	25	40	24	23	20	30	26	26
Cesium-137 (pc/day)	July	150	125	25	120	145	135	130	—	105	270	147	147
	Aug	190	145	50	—	170	125	105	—	95	235	169	169
	Sept	175	80	75	135	135	85	65	75	125	215	156	156
Barium-140 (pc/day)	July	<10	<10	<10	<10	<10	<30	<30	—	<30	<10	0	16
	Aug	<10	<10	<10	—	<10	<30	<30	—	<30	<10	0	17
	Sept	<10	<10	<10	10	<20	<20	<30	<10	<30	<10	0	16
Iodine-131 (pc/day)	July	<10	<10	<10	<10	<10	<30	<30	—	<30	<10	0	16
	Aug	<10	<10	<10	—	<10	<30	<30	—	<30	<10	0	17
	Sept	<10	<10	<10	<10	<20	<20	<30	<10	<30	<10	0	16

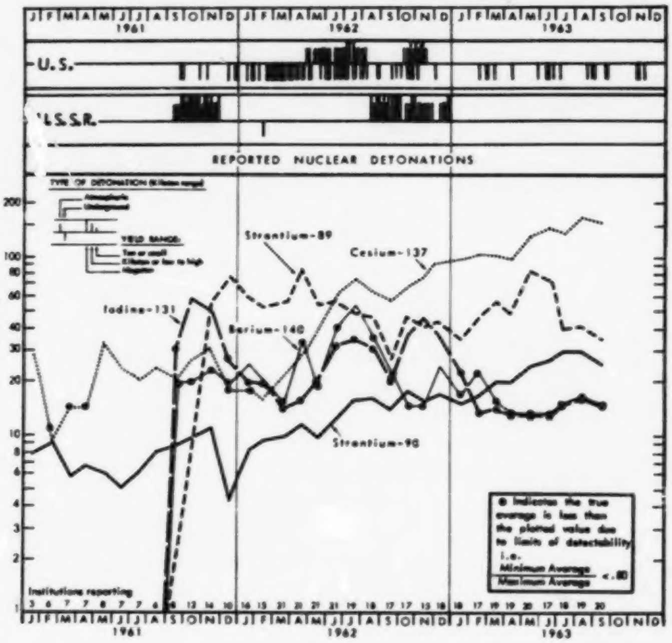


FIGURE 2.—RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES—AVERAGE OF INSTITUTIONS

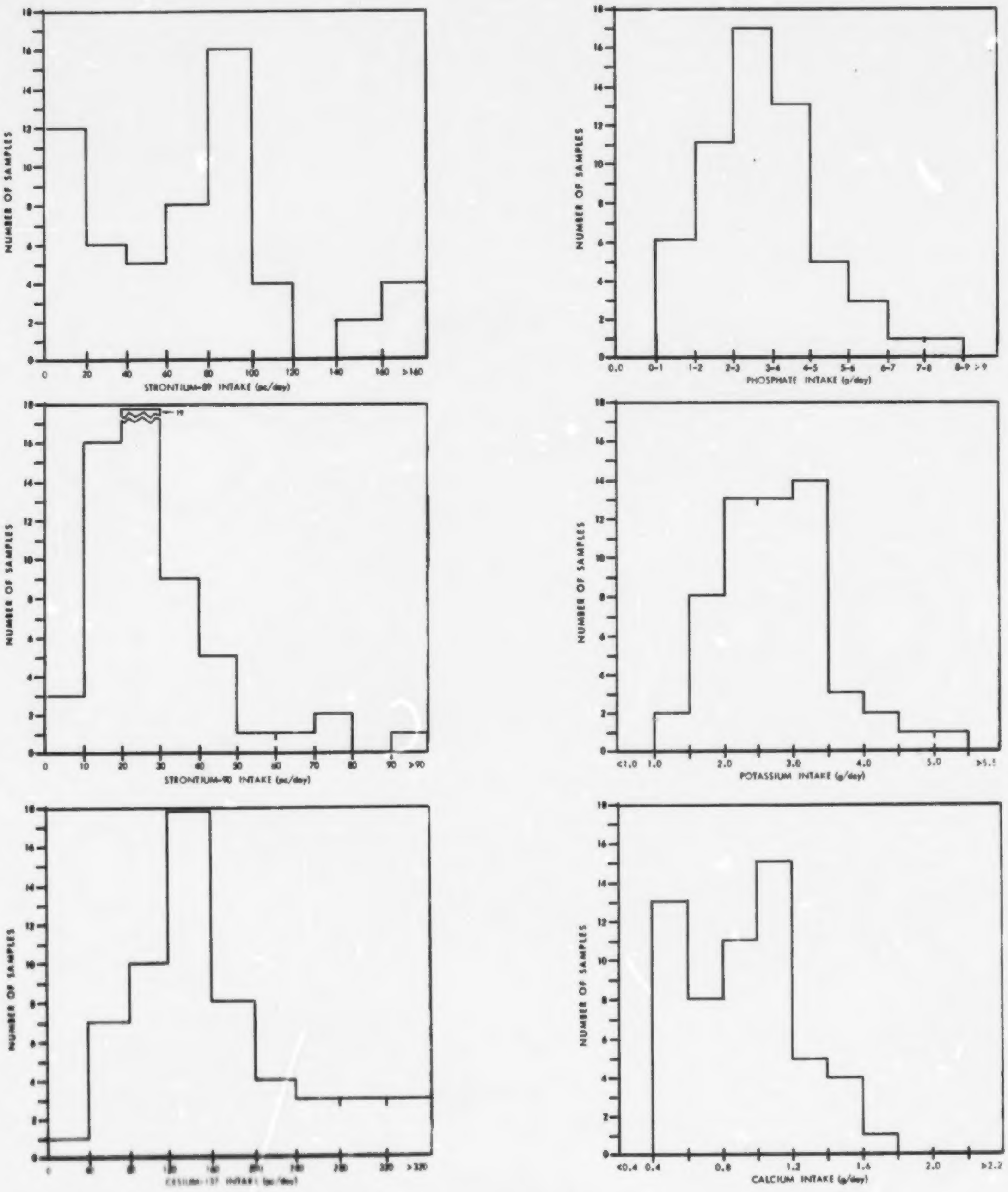


FIGURE 3.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF MATERIALS IN INSTITUTIONAL DIETS FOR JULY—SEPTEMBER 1963

136

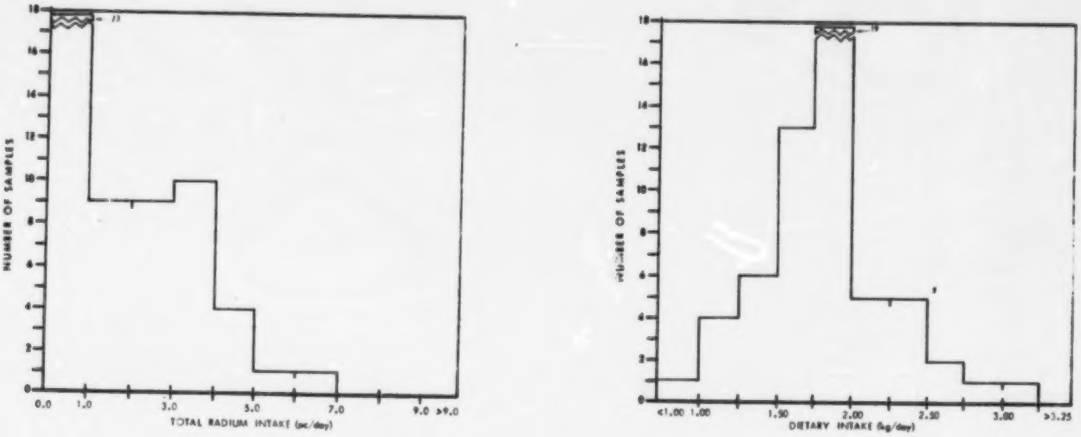


FIGURE 3.—DISTRIBUTION OF THE NUMBER OF SAMPLES VERSUS INTAKE OF MATERIALS IN INSTITUTIONAL DIETS FOR JULY—SEPTEMBER 1963—Continued

REFERENCES

(*1*) Anderson, E. C., and D. J. Nelson, Jr.: Surveillance for Radiological Contamination in Foods, *American Journal of Public Health, 52*: 1391–400 (September 1962).

(*2*) Chen, P. S., Jr., A. R. Terepka, and H. C. Hodge: The Pharmacology and Toxicology of the Bone Seekers, *Annual Review of Pharmacology 1*:369–96 (1961).

(*3*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(*4*) Chadwick, Donald R. and Conrad P. Straub: Considerations in Establishing Radiation Protection Standards for Radioactivity in the Environment, *Radiological Health Data, 3*:159–65 (May 1962).

Previous coverage in *Radiological Health Data*:

Period	Issue
March–June 1962	*December 1962*
July–September 1962	*April 1963*
October–December 1963	*July 1963*
January–March 1963	*September 1963*
April–June 1963	*December 1963*

TRI-CITY DIET STUDY,[1] MAY-JULY 1963

Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U. S. Department of Agriculture (*1*), the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL-113 (*2*).

Results obtained from the programs thirteenth sampling May-July 1963 are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Discussion

The previously noted geographic pattern of distribution of strontium-90 in the diet is seen to persist in the last sampling. Levels have been highest in New York City and lowest in San Francisco. Partly due to its high annual consumption, milk continues to be the predominant source of strontium-90 in the diet.

The sharp increases in the daily intake of strontium-90 at each of the cities between the first and second quarters of 1963 are evident in figure 1. These increases were due principally to the higher strontium-90 content of milk. Dairy cows in the milksheds of the three cities were put out to pasture during this period and presumably consumed grass heavily contaminated with strontium-90 deposited during the spring and early summer.

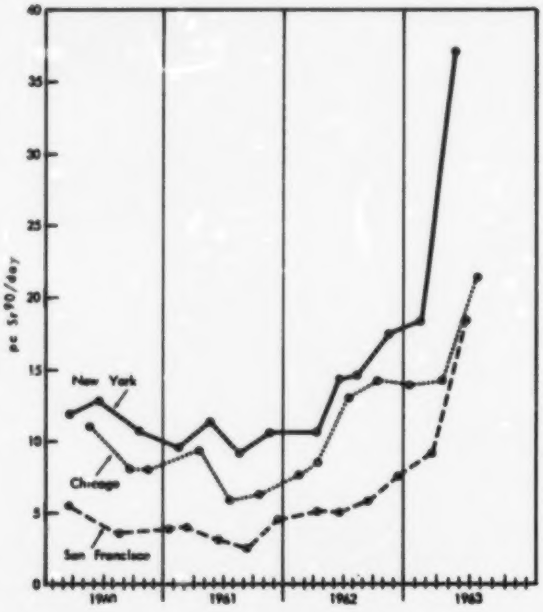


FIGURE 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

REFERENCES

(*1*) U. S. Department of Agriculture: *Food Consumption of Households in the United States, Report No. 1*

---

[1] Summarized from *Fallout Program Quarterly Summary Report, HASL 142*:182-4, Office of Technical Services, Department of Commerce, Washington 25, D. C., (January 1964), price $4.00.

TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—THIRTEENTH SAMPLING

Food category	Average U. S. consumption		New York City May 1963		Chicago July 1963		San Francisco June 1963	
	diet (kg/yr)	Calcium (g/yr)	pc/kg[a]	pc/yr	pc/kg	pc/yr	pc/kg	pc/yr
Bakery products	37	37.0	15.0 ±2.8	555	18.4 ±1.0	679	12.0 ±1.1	445
Whole grain products	11	10.0	51.1 ±1.8	562	47.2 ±2.0	519	18.6 ±1.6	204
Eggs	16	9.1	3.4 ±0.1	54	9.4 ±0.2	150	5.9 ±0.2	95
Fresh vegetables	43	15.0	20.3 ±0.6	873	6.4 ±0.6	276	11.2 ±0.6	482
Root vegetables	17	6.1	7.6 ±0.5	129	4.1 ±0.4	70	4.0 ±0.5	67
Milk	221	234.3	40.8 ±1.0	9017	17.1 ±0.7	3777	19.3 ±0.7	4263
Poultry	17	9.2	0.7 ±0.1	12	2.9 ±0.2	50	3.5 ±0.2	60
Fresh fish	8	10.8	0.8 ±0.1	6	1.3 ±0.1	10	0.8 ±0.1	6
Flour	43	8.6	23.5 ±0.6	1011	28.3 ±0.7	1215	7.0 ±0.3	301
Macaroni	3	0.7	14.0 ±0.6	42	16.8 ±0.6	50	12.3 ±0.7	37
Rice	3	1.1	1.8 ±0.3	5	4.1 ±0.4	12	2.8 ±0.3	8
Meat	73	10.9	0.7 ±0.2	51	2.3 ±0.1	171	2.4 ±0.2	176
Shellfish	1	0.8	2.8 ±0.5	3	1.2 ±0.1	1	1.5 ±0.3	2
Dried beans	3	2.9	14.0 ±1.8	42	lost	[b]90	6.5 ±1.9	20
Fresh fruit	68	13.6	11.1 ±3.8	755	2.8 ±0.3	190	3.0 ±0.3	203
Potatoes	45	5.8	5.8 ±0.6	216	2.3 ±0.2	104	1.1 ±0.4	49
Canned fruit	26	1.3	1.4 ±0.2	36	1.6 ±0.2	42	1.2 ±0.1	30
Fruit juices	19	1.7	2.3 ±0.3	44	3.3 ±0.3	62	3.8 ±0.3	72
Canned vegetables	20	4.2	6.5 ±0.5	130	8.1 ±0.6	162	1.9 ±0.4	37
Annual Intake	674	383		13,543		7,630		6,557
pc Sr^{90}/g Ca in total diet				35.3		20.0		17.1

[a] Error terms are one standard deviation (due to counting).
[b] Estimated from April 1963 sampling.

(1955), Household Food Consumption Survey, Superintendent of Documents, Government Printing Office, Washington 25, D. C. (December 1956), price $1.00.

(2) U. S. Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL–113*:85–89, Office of Technical Services, Department of Commerce, Washington 25, D. C. (July 1, 1961), price $2.50.

Recent coverage in *Radiological Health Data*:

Period	Issue
Eighth sampling (April 1962)	*January 1963*
Ninth sampling (June–July 1962)	*March 1963*
Tenth sampling (August–September 1962)	*June 1963*
Eleventh sampling (November 1962–January 1963)	*September 1963*
Twelfth sampling (February–April 1963)	*December 1963*

Section III.—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, SEPTEMBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service National Water Quality Network since its initiation in 1957. Beginning with the establishment of 50 sampling points, this network has expanded to 128 stations as of February 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the Network provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the Network are published in an annual compilation (*1–6*).

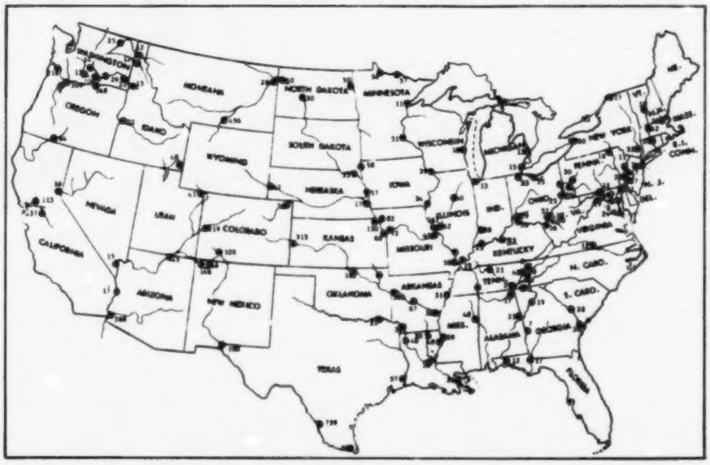

WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
MINNESOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
WISCONSIN
MICHIGAN
NEW YORK
ME.
VT.
N.H.
MASS.
R.I.
CONN.
N. J.
DEL.
PENNA.
OHIO
IND.
ILLINOIS
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
KENTUCKY
VIRGINIA
W. VA.
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TENN.
N. CARO.
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATER AT NATIONAL WATER QUALITY NETWORK SAMPLING STATIONS, SEPTEMBER 1963

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations for gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium–90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established Network stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit rapid detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once a month except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Cincinnati Laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not corrected by extrapolation to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium–90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning November 1962 the frequency of strontium–90 analyses was reduced to twice a year at each sampling point except those stations immediately below nuclear installations. Until the fourth quarter of 1961, the method used for determining strontium–90 was that described in the above reference (*7*). Tributyl phosphate was used to extract ingrown yttrium–90 from the purified, coprecipitated strontium–90. Beginning with the first quarter of 1962, a modification of a procedure described by Harley has been used (*8*). The yttrium–90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anti-coincidence, end-window proportional counter.

Results

Table 1 presents September 1963 results of alpha and beta analyses of U. S. raw surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary; reanalysis of some samples and some analyses which are not completed at the time of this report will be included in the Network's Annual Compilation of Data (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations made on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter with the exception that when all samples have zero pc/liter the mean is reported as zero. When the calculated mean is between zero and 0.5 the mean is reported as < 1 pc/liter. The most recent quarterly strontium–90 results appeared in the January 1964 *Radiological Health Data* (*9*).

TABLE 1.—RADIOACTIVITY IN U.S. SURFACE WATERS, SEPTEMBER 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	9	21	30	0	0	0
Animas River:						
Cedar Hill, N. Mex	6	10	16	1	1	2
Apalachicola River:						
Chattahoochee, Fla	1	16	17	0	0	0
Arkansas River:						
Coolidge, Kansas	272	43	315	24	21	45
Ponca City, Okla	98	64	162	10	2	12
Fort Smith, Ark	266	34	300	46	0	46
Little Rock, Ark	29	38	67	3	1	4
Pendleton Ferry, Ark	3	15	18	1	2	3
Bear River:						
Preston, Idaho	5	44	49	0	1	1
Big Horn River:						
Hardin, Mont	405	51	456	61	9	70
Big Sioux River:						
Sioux Falls, S. Dak	34	24	58	1	0	1
Chattahoochee River:						
Atlanta, Ga	8	11	19	0	0	0
Columbus, Ga	0	7	7	0	0	0
Lanett, Ala	12	11	23	1	0	1
Chena Slough:						
Fairbanks, Alaska	3	6	9	0	0	0
Clearwater River:						
Lewiston, Idaho	4	9	13	1	0	1
Clinch River:						
Clinton, Tenn	2	6	8	0	<1	<1
Kingston, Tenn	6	42	48	0	0	0
Colorado River:						
Loma, Colo	175	44	219	16	7	23
Page, Ariz	3	42	45	1	7	8
Boulder City, Nev	0	13	13	0	8	8
Parker Dam, Calif-Ariz	4	13	17	0	6	6
Yuma, Ariz	0	288	288	0	0	0
Columbia River:						
Northport, Wash	4	21	25	1	1	2
Wenatchee, Wash	0	14	14	0	1	1
Pasco, Wash	42	662	704	0	0	0
McNary Dam, Ore	34	332	368	0	1	1
Bonneville, Ore	16	293	309	0	1	1
Clatskanie, Ore	12	204	216	0	<1	<1
Cumberland River:						
Clarksville, Tenn	6	15	21	1	0	1
Connecticut River:						
Wilder, Vt	15	18	33	0	0	0
Northfield, Mass	24	18	42	1	0	1
Enfield Dam, Conn	9	15	24	0	0	0
Cuyahoga River:						
Cleveland, Ohio	4	31	35	0	2	2
Delaware River:						
Martins Creek, Pa	2	9	11	0	0	0
Trenton, N. J	1	16	17	0	0	0
Philadelphia, Pa	8	18	26	1	1	2
Escambia River:						
Century, Fla	7	5	12	1	0	1
Great Lakes:						
Duluth, Minn	3	8	11	0	0	0
Sault Ste. Marie, Mich	1	5	6	0	1	1
Milwaukee, Wis	3	15	18	0	1	1
Gary, Ind	2	11	13	0	0	0
Port Huron, Mich	4	9	13	0	0	0
Detroit, Mich	4	11	15	0	0	0
Buffalo, New York	9	21	30	0	0	0
Green River:						
Dutch John, Utah	4	37	41	0	3	3
Hudson River:						
Poughkeepsie, N. Y	4	28	32	0	0	0
Illinois River:						
Peoria, Ill	3	37	40	0	0	0
Grafton, Ill	138	24	162	21	0	21
Kanawha River:						
Winfield Dam, W. Va	8	22	30	0	0	0
Klamath River:						
Keno, Ore	7	17	24	0	1	1
Kansas River:						
De Soto, Kans	78	72	150	7	5	12
Maumee River:						
Toledo, Ohio	6	27	33	1	1	2
Little Miami River:						
Cincinnati, Ohio	16	13	29	2	2	4
Merrimack River:						
Lowell, Mass	12	26	38	0	0	0
Mississippi River:						
St. Paul, Minn	8	43	51	0	2	2
Dubuque, Iowa	4	35	39	0	1	1
Burlington, Iowa	7	27	34	0	1	1
E. St. Louis, Ill	8	34	42	0	2	2
Cape Girardeau, Mo	14	44	58	1	3	4
W. Memphis, Ark	4	27	31	0	2	2
Vicksburg, Miss	15	24	39	1	1	2
Delta, La	16	32	48	0	2	2
New Orleans, La	1	25	26	0	2	2
Missouri River:						
Williston, N. Dak	11	39	50	1	5	6
Bismarck, N. Dak	7	23	30	0	4	4
Yankton, S. Dak	0	33	33	0	5	5
Omaha, Nebr	27	30	57	9	4	13
St. Joseph, Mo	50	32	82	8	4	12
Kansas City, Kans	31	35	66	9	4	13
Missouri City, Mo	27	45	72	3	5	8
St. Louis, Mo	14	35	49	2	0	2
Monongahela River:						
Pittsburgh, Pa	0	20	20	0	0	0
North Platte River:						
Henry, Nebr	10	37	47	1	22	23
Ohio River:						
Toronto, Ohio	2	23	25	0	1	1
Addison, Ohio	5	32	37	0	0	0
Huntington, W. Va	2	14	16	1	1	2
Cincinnati, Ohio	0	20	20	0	1	1
Louisville, Ky	4	29	33	0	0	0
Evansville, Ind	2	21	23	1	1	2
Cairo, Ill	0	19	19	0	<1	<1
Ouachita River:						
Bastrop, La	7	23	30	2	1	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	11	12	0	0	0
Platte River:						
Plattsmouth, Nebr	124	46	170	10	2	12
Potomac River:						
Williamsport, Md	0	12	12	0	2	2
Great Falls, Md	0	19	19	0	0	0
Washington, D. C	2	27	29	0	1	1
Rainy River:						
Baudette, Minn	7	47	54	0	0	0
International Falls, Minn	8	49	57	0	0	0
Raritan River:						
Perth Amboy, N. J. (5-ft. Below Surface)	4	13	17	0	3	3
Perth Amboy, N. J. (5-ft. Above Bottom)	2	10	12	0	3	3
Red River, North:						
Grand Forks, N. Dak	13	37	50	0	0	0
Red River, South:						
Denison, Tex	0	23	23	0	0	0
Index, Ark	4	35	39	0	1	1
Bossier City, La	5	35	40	0	0	0
Alexandria, La	4	26	30	0	3	3
Rio Grande River:						
Alamosa, Colo	26	77	103	1	9	10
El Paso, Tex	87	21	108	12	3	15
Laredo, Tex	694	45	739	47	3	50
Brownsville, Tex	7	21	28	0	3	3
Roanoke River:						
John H. Kerr Resr/Dam, Va	2	10	12	1	0	1
Sabine River:						
Ruliff, Tex	11	46	57	0	1	1
Sacramento River:						
Courtland, Calif	98	15	113	2	0	2
San Joaquin River:						
Vernalis, Calif	12	25	37	1	5	6
San Juan River:						
Shiprock, N. Mex	120	26	146	18	10	28
St. Lawrence River:						
Massena, N. Y	4	13	17	1	1	2
Schuylkill River:						
Philadelphia, Pa	3	24	27	0	0	0
Savannah River:						
North Augusta, S. C	12	16	28	0	0	0
Port Wentworth, Ga	4	16	20	<1	0	<1
Shenandoah River:						
Berryville, Va	15	14	29	0	0	0
Ship Creek:						
Anchorage, Alaska	2	10	12	0	0	0
Snake River:						
Ice Harbor Dam, Washington	3	19	22	0	0	0
Wawawai, Wash	6	20	26	0	3	3
Payette, Idaho	7	15	22	0	4	4
South Platte River:						
Julesburg, Colo	18	58	76	4	32	36
Spokane River:						
Post Falls, Idaho	3	9	12	0	0	0
Susquehanna River:						
Sayre, Pa	6	12	18	0	0	0
Conowingo, Md	0	17	17	0	1	1
Tennessee River:						
Lenoir City, Tenn	3	17	20	0	0	0
Chattanooga, Tenn	1	21	22	1	0	1
Bridgeport, Ala	0	17	17	0	0	0
Pickwick Landing, Tenn	5	24	29	1	0	1
Tombigbee River:						
Columbus, Miss	14	34	48	1	1	2
Truckee River:						
Farad, Calif	4	14	18	0	0	0
Wabash River:						
New Harmony, Ind	4	24	28	0	5	5
Willamette River:						
Portland, Ore	6	3	9	0	0	0
Yakima River:						
Richland, Wash	0	13	13	0	2	2
Yellowstone River:						
Sidney, Mont	239	45	284	7	4	11
Maximum	694	662	739	61	32	70
Minimum	0	3	6	0	0	0

Note: These date are preliminary; reanalysis of some samples and analyses which are not complete at the time of this report will be included in the network's *Annual Compilation of Data* (6).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the September 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Network results for the years 1957–1962 have been summarized by Weaver *et al* (*10*).

Discussion

Analysis of the preliminary September 1963 data indicates several elevated levels of alpha and beta activity (pc/liter) in the suspended solids fraction. The monthly average suspended alpha and beta activities in the Rio Grande River at Laredo, Texas were 47 and 694 pc/liter, respectively. Samples from other stations on this river indicate no unusual values. In the Big Horn River at Hardin, Montana, the monthly average was 61 pc/liter of suspended alpha activity and 405 pc/liter of suspended beta activity. The dissolved alpha and beta activities were not significantly different from those commonly observed at these sampling points. The samples associated with these unusually high averages contained large quantities of suspended solids. Thus, only quite small aliquots could be used in the laboratory determinations to avoid excessive self-absorption. In such cases the relatively large multiplication factor, together with the usual range of counting errors associated with standard counting periods, can result in apparently abnormal levels of radioactivity. The specific activity (pc/g) of the samples discussed above was determined and found to be comparable to the specific activity observed normally in samples from these stations. The apparent increased activity, therefore, may be attributed to the extremely high suspended solids content of the samples and essentially of natural origin.

On the Columbia and Colorado Rivers, the monthly dissolved beta activity averages were greater than 100 pc/liter. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operation facility had averages of between 204 and 662 pc/liter. It was observed that the concentration diminished progressively downstream from the facility. An average of 288 pc/liter of dissolved beta activity was recorded on the Colorado River at Yuma, Arizona. Other stations on this river reported concentrations not nearly as high. While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentrations do not exceed 1000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663*, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington D. C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*8*) Harley, J. H.: Radiochemical Determination of Strontium–90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(*9*) Public Health Service: National Water Quality Network, July 1963, *Radiological Health Data 5*:3–11 (in draft) (January 1964).

(*10*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957–1962, *Radiological Health Data, 4*:306–16 (June (1963).

(*11*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association 53*:704 (June 1961).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402. (March 1963), price 30 cents.

---

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN CALIFORNIA SURFACE WATER,[1] JANUARY-JUNE 1963

Bureau of Radiological Health, State of California Department of Public Health

Results obtained by the Bureau of Radiological Health in its monitoring of California surface water during the period January to June 1963 are summarized below. The importance of this facet of the Bureau's environmental surveillance program stems from the fact that most of California's domestic water supplies come from surface sources. Radioactivity in such water supplies consists of the natural radioactivity in surface streams and any radioactivity that may be added by the discharge of sewage or industrial waste effluents into streams. These water supplies may also contain radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Most of the supplies sampled represent raw surface waters, although a few wells, along with some water supplies that use infiltration galleries, are also sampled (figure 1).

It is necessary to monitor domestic water supplies on a continuing basis, since it is impossible to forecast levels of radioactivity in these supplies on the basis of radioactivity in rain, snow, or surface streams. The Bureau has established a monthly sampling schedule whereby 500-ml samples are collected and the total solids are analyzed for alpha and beta radioactivity. In addition, a three-liter sample is collected each month for a period of six months to make up a composite of approximately five gallons for strontium-90 analysis.

Laboratory Methods.

Radionuclide analyses of water are carried out in the Sanitation and Radiation Laboratory. All measurements of alpha and alpha-plus-beta activities are made with windowless gas-flow proportional counters. Five proportional counters, four of which are manual counters, are available to the Bureau. Two of the manual units have specially-designed, shielded external detectors which reduce the alpha and beta backgrounds to 0.01 and 30 cpm, respectively. In the case of the two integrally-constructed manual units the relatively high beta background has been reduced to 40 cpm by partial shielding of the scaler with lead bricks. The fifth counter is an automatic unit which has a beta background of about 15 cpm.

The Department's maximum capacity for alpha and beta radioactivity measurements during a normal work week on these instruments is 500 thirty-minute counts. Counting methods used are in accordance with U. S. Public Health Service recommended procedures (*1*).

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-the-dissolved-solids in raw surface water in California from Janu-

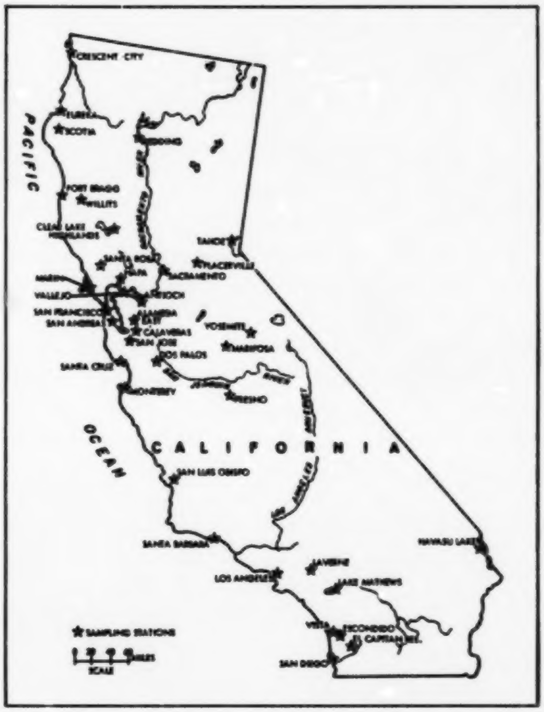

CRESCENT CITY
EUREKA
SCOTIA
PACIFIC
REDDING
FORT BRAGG
WILLITS
CLEAR LAKE HIGHLANDS
TAHOE
PLACERVILLE
SANTA ROSA
NAPA
SACRAMENTO
MARIN
VALLEJO
ANTIOCH
SAN FRANCISCO
SAN ANDREAS
ALAMEDA EAST
CALAVERAS
YOSEMITE
SAN JOSE
DOS PALOS
MARIPOSA
SANTA CRUZ
MONTEREY
FRESNO
OCEAN
C A L I F O R N I A
SAN LUIS OBISPO
SANTA BARBARA
HAVASU LAKE
LAVERNE
LOS ANGELES
LAKE MATHEWS
VISTA
ESCONDIDO
EL CAPITAN RES.
SAN DIEGO
SAMPLING STATIONS
0 20 40 60 MILES
SCALE

FIGURE 2.—CALIFORNIA SURFACE WATER SAMPLING STATIONS

---

[1] "Radiological Health News," Vol 2 Nos. 3 and 4, July and October 1963, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

144

TABLE 1.—GROSS BETA ACTIVITY IN CALIFORNIA SURFACE WATER, JANUARY-JUNE 1963

[Concentrations in pc/liter]

Sampling station	Jan.	Feb.	Mar.	Apr.	May	June
Antioch	27.7	99.4	59.9	97.0	35.7	73.9
Chula Vista	76.6	a				
Clearlake Highlands	0^{b}	80.0	0^{c}	24.8^{b}		87.8
Crescent City	0^{b}	225	0^{b}	0^{b}	7.5^{b}	43.6
Escondido	31.7	53.2	32.6	24.2^{b}	29.5	28.9
Eureka	25.9	0^{b}	0^{b}	46.5	8^{b}	
Fort Bragg	0^{b}	0^{b}	0^{b}	39.9	13.7^{b}	2.1^{b}
Fresno						
Lake Millerton	0^{b}	44.6^{b}	73.9^{b}	29.5	31.5	69.6
Marin Municipal Water District						
Nicasio Reservoir	0^{b}	106	91.9			
Mariposa	24.3	92.5	0^{b}	108.2	88.1	35.8
Metropolitan Water Company of Southern California						
Lake Havasu	0^{b}	0^{b}	25.5		0^{b}	18.5
Lake Matthews	0^{b}	0^{b}	0^{b}	11.6^{b}	30.0	11.6^{b}
Monterey	0^{b}	22.2	42.2	50.1	9.1^{b}	11.1^{b}
Napa	0^{b}				38.2	19.5^{b}
North Marin County Water District				56.0	68.5	47.0
Oroville						
Wyandotte Irrigation District		40.5		163.2		24.7^{b}
California Water Service	30.2		39.8		27.4	
Piacerville					39.2	70.7
Redding	0^{b}	48.0	0^{b}	55.2	38.1	47.5
Sacramento	28.1	78.6	31.8	30.3	33.7	
San Francisco Water Department						
Alameda East	0^{b}	57.7	33.8	94.3	33.0	77.9
Brightside Weir	0^{b}	0^{b}	0^{b}	36.4	14.6^{b}	100.5
Calaveras Reservoir	0^{b}	81.4	0^{b}	18.1^{b}	50.1	24.7
Crystal Springs Raw Outlet	0^{b}	28.4	0^{b}	26.0		81.4
Crystal Springs Line 1	13.9^{c}	27.9^{c}	32.2^{c}	41.1^{b}	42.9^{b}	28.9^{b}
Crystal Springs Line 2					76.5	
Hetch Hetchy			61.1		186.6	71.6
Lombard Reservoir	0^{b}	93.3	23.5	21.0^{c}		
San Andreas Line 2	9.8^{c}	49.3^{c}	41.3^{c}	57.8^{c}	42.8^{c}	50.6^{c}
University Mound	0^{b}	0^{b}	22.6	70.9		
San Jose		0^{b}	30.3	0^{b}	38.9	
San Luis Obispo	0^{b}	118.3				
Santa Barbara	0^{b}	0^{b}	0^{b}	42.5	14.8^{b}	
Santa Cruz	18.3	0^{b}	27.6	17.2^{b}	20.9^{b}	33.7
Santa Rosa	31.9	31.6	0^{b}	72.2	16.6^{b}	55.2
Scotia	0^{b}	0^{b}	0^{b}	50.5	14.5^{b}	11.1^{b}
Tahoe City			58.2	55.4	31.5	
Vallejo						
Fleming Hill	14.0	55.4	46.1	60.6	48.6	
Swanzy Reservoir	0^{b}	29.3	34.3	59.1	23.0	
Vista	0^{b}	31.2	26.8			27.2
Willits				103.7	33.8	29.5
Yosemite	0^{b}	110	24.0	72.4	54.5	143.0

[a] Blank space indicates no sample collected or analyzed.
[b] The counting rate of the sample is not equal to at least twice the 0.95 statistical counting error but the value reported is the best available estimate.
[c] Average of more than one sample for the month.

ary through June 1963. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has, in general, been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water is observed in spite of some increase in fallout.

REFERENCES

(1) Division of Radiological Health: *Radionuclide Analyses of Environmental Samples, R59–6*, Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati 26, Ohio (November 16, 1959).

Previous *coverage in Radiological Health Data*:

Period	Issue
1961—June 1962	*April 1963*
July—December 1962	*September 1963*

Section IV.—Other Data

IODINE-131 IN *POST-MORTEM* HUMAN THYROIDS

Frances I. Visalli and Abraham S. Goldin[1]

The iodine–131 burdens of post-mortem thyroids from New England residents coming to autopsy at two lying-in hospitals and one children's hospital were measured at the Northeastern Radiological Health Laboratory from May 1962 to January 1963. Nuclear weapons tests were conducted preceding and during this same period by the United States and by the U. S. S. R. and the following results are observations made on available thyroid tissue during that period. Practically all of the samples were obtained from peri- or pre-natal deaths, or as a result of deaths of infants or children form disease. The population represented can therefore not be considered as typical.

Method of Measurement

The method of measurement used was gamma scintillation spectroscopy. The thyroid sample as received in a small plastic vial was placed on a 4 x 4-inch sodium iodide crystal (thallium activated) inside a 6-inch-thick iron shield. The detector was connected to a multichannel analyzer and the iodine–131 content calculated from the counting rate in the region from 0.33 to 0.39 Mev after correction for background. This is essentially the method used by Eisenbud *et al.* *(1)*. There was no measurable contribution in these small samples from potassium–40 or cesium–137. With this equipment, in a 50-minute count, the measured 2σ counting error for samples of low radioiodine content was approximately 2.6 counts per minute, corresponding to 9 picocuries. After these values were corrected for radioactive decay from the time of death to the time of measurement, the 2σ error was usually about ± 13 to 17 picocuries for the entire sample. In a few cases, where a relatively long period intervened between the time of death and the time of measurement, the error was greater than the above range. The minimum detectable activity is defined as the smallest value at which the confidence interval, the lower limit of which is established by the observed value minus 2 standard deviations due to counting, remains above zero. Since many of the samples were quite small, the error, when expressed as picocuries per gram, becomes numerically large when compared to the sample value.

Results

Since both the gross sample rate and the background rate are subject to random statistical variations, the difference between them (net rate) may be less than zero when samples *of zero or very low activity are being measured.* The actual values, whether positive or negative, are given in table 1. The activity of individual samples should be considered "not detectable" when the reported value is negative or is less than the reported counting error, but the actual values should be used in averaging.

---

[1] Miss Visalli is in charge of the iodine–131 thyroid studies and Dr. Goldin is Deputy Officer-in-Charge and Director of the Research Program, Northeastern Radiological Health Laboratory, Division of Radiological Health, Public Health Service, 109 Holton Street, Winchester, Massachusetts.

The results of iodine-131 measurements made on thyroids from persons in New England *between May 1962 and January 1963* are shown in table 1.

In nearly all of these cases, the thyroid was removed for *post-mortem* examination and the portion submitted was that part of the thyroid not required by the pathologist in his examination. Information as to total thyroid size or

TABLE 1.—IODINE-131 IN *POST MORTEM* THYROIDS

Sample number	Date of death	Age at death	Sex	Weight (pounds)	Weight of sample submitted (grams)[a]	Iodine-131 in sample[b]	
						(pc)	(pc/g)
GROUP I							
0-100	5/14/62	13 yr 11 mo	F		2.7	0 ± 14	0 ± 5
0-101	5/10/62	2 yr 5 mo	M		0.5	[c] −2 ± 21	[c] −4 ± 42
0-102	5/15/62	4 yr 2 mo	F	44	1.0	9 ± 15	9 ± 15
0-103	5/16/62	2.5 mo	M	15	0.4	8 ± 14	20 ± 35
0-104	5/15/62	7 yr 3 mo	F	43	8.5	430 ± 29	51 ± 3.4
0-105	5/23/62	24 hrs.	M	2	0.5	[c] −12 ± 14	[c] −27 ± 31
0-106	5/25/62	3 yr 9 mo	F	40	2.6	[c] −3 ± 16	[c] −1.2 ± 6.1
0-107	5/27/62	10 days	F	6.2	0.6	0.4 ± 14	0.7 ± 23
0-108	5/30/62	13 yr 7 mo	M	117	6.4	7 ± 16	1.1 ± 2.5
0-109	5/30/62	1 yr 11 mo	M	25	0.5	[c] −5 ± 16	[c] −10 ± 32
0-110	5/30/62	8 yr 8 mo	M	48	5.4	15 ± 16	2.8 ± 3.0
0-111	5/30/62	14 years	F	132	3.9	2 ± 16	0.5 ± 4.1
0-112	6/ 3/62	3 yr 11 mo	F	44	1.6	5 ± 13	3.1 ± 8.1
0-113	6/ 5/62	4 yr 7 mo	F	30	1.9	7 ± 16	3.7 ± 8.4
0-114	6/ 8/62	1 mo	M	2	0.3	4 ± 12	13 ± 40
0-115	6/11/62	4 mo	F	13	0.4	6 ± 12	15 ± 30
0-117	6/16/62	7 yr 1 mo	M	60	1.7	[c] −27 ± 27	[c] −16 ± 16
0-118	6/23/62		M	4.6	0.7	[c] −12 ± 16	[c] −17 ± 23
0-119	6/22/62	20 years	F	100	3.1	[c] −4 ± 17	[c] −1.3 ± 5.5
0-120	6/23/62	23 days	F	3	0.6	3 ± 16	5 ± 27
0-121	6/25/62	5 days	M	7.6	0.4	[c] −5 ± 13	[c] −12 ± 33
0-122	6/27/62	6 yr 10 mo		43	1.3	[c] −7 ± 12	[c] −5.4 ± 9.2
0-123	6/29/62	4 yr 4 mo	M	35	1.1	[c] −7 ± 10	[c] −6.4 ± 9.1
0-124	6/28/62	31 hours	M	4.8	0.5	[c] −4 ± 11	[c] −8 ± 22
0-125	7/ 2/62	30 hours		6.1	0.6	12 ± 20	20 ± 33
0-126	7/ 2/62	38 hours	F	3.4	0.2	3 ± 20	15 ± 100
0-130	7/10/62	12 hours	F	2.6	0.4	7 ± 15	18 ± 38
0-131	7/10/62	5 hours	F	2.4	0.4	[c] −2 ± 15	[c] −5 ± 38
0-132	7/11/62	1 yr 6 mo	F	22	0.9	12 ± 18	13 ± 20
0-133	7/17/62	1 mo	F	7	0.5	4 ± 11	8 ± 22
0-134	7/17/62	13 min	M	4.6	0.4	[c] −2 ± 20	[c] −5 ± 50
0-135	7/20/62	1 mo	F	4.2	0.1	2 ± 15	20 ± 150
0-136	7/24/62	4½ hrs	M	5.3	0.7	20 ± 11	29 ± 16
0-137	7/24/62	Stillborn	M	7.4	0.3	8 ± 11	27 ± 37
0-138	7/25/62	15 yr 7 mo	M	103	10.9	51 ± 19	4.7 ± 1.7
0-139	8/21/62	8 yr 6 mo	M	85	2.7	1 ± 15	0.4 ± 5.6
0-140	8/30/62	4 mo	F	11.5	0.5	[c] −2 ± 26	[c] −4 ± 52
Average of 37 samples							4.3
GROUP II							
0-141	9/20/62	24 hrs	F	1.5	0.3	0 ± 17	0 ± 57
0-142	9/15/62	5 yr 9 mo	M	48	2.3	4 ± 25	2 ± 11
0-143	9/21/62	6 years	M	50	3.9	16 ± 15	4.1 ± 3.9
0-144	9/25/62	34 years	M		7.0	5 ± 17	0.7 ± 2.4
0-145	10/10/62	18 days	M	6.3	0.6	7 ± 30	12 ± 50
0-146	10/15/62	Stillborn	M	7.2	0.8	1 ± 22	1 ± 28
0-147	10/15/62	Stillborn	F	1.5	0.4	6 ± 19	15 ± 48
0-148	10/17/62	Stillborn	F	2.5	0.4	0 ± 18	0 ± 45
0-149	10/17/62	2 mo	M	10	0.7	9 ± 17	13 ± 24
0-150	10/22/62	15 yr 7 mo	M	124	7.4	118 ± 15	16 ± 2
0-151	10/24/62	11 hrs	F	4.9	0.5	23 ± 11	46 ± 22
0-152	10/24/62	11 hrs	M	4.4	0.8	14 ± 10	18 ± 13
0-153	10/26/62	45 hrs	M	5.2	0.6	35 ± 13	58 ± 22
0-154	10/26/62	13¾ hrs	F	6.3	1.0	30 ± 12	30 ± 12
0-155	10/21/62	Stillborn	F	7.6	0.7	15 ± 41	22 ± 59
0-156	11/ 4/62	2 hrs	F	4.2	0.9	8 ± 13	9 ± 14
0-157	12/13/62	22¾ hrs		9.8	0.8	7 ± 29	9 ± 36
0-158	12/14/62	5 days	F	4	0.2	0 ± 52	0 ± 260
0-159	12/21/62	3 mo	F	10.8	1.3	0 ± 25	0 ± 19
0-160	1/10/63	Stillborn	F	5.6	0.8	23 ± 18	29 ± 22
Average of 20 samples							14.2

[a] The weight of sample submitted does not constitute the entire thyroid mass in all cases.
[b] Corrected to date of death; error shown is the 2σ statistical counting error.
[c] Negative values arise from subtracting statistically fluctuating background. (see *Results* above).

total thyroid burden is not available. All the values provided should be considered as representing only that portion of the thyroid furnished.

Environmental levels of radioiodine in New England, as measured in market milk (*2*) and in institutional diet samples (*3*) were near or below the limits of detectability from May 1962 until about September 15, 1962. In addition, air particulate levels did not indicate the presence of fresh fission products (*4*). Thus, the data of table 1 may be best considered in two groups. Group I consists of 37 samples, numbered 0–100 through 0–140, which were collected when the environmental levels were relatively low. There are three samples in Group I in which the measured activity was greater than the 2σ error, indicating the presence of radioactive iodine. In one case (0–104) the level is quite high and examination of the spectrum obtained indicated that iodine–131 was definitely present. The source of this radioiodine is unknown; neither the administration of radioiodine nor its non-administration could be definitely established. There was also an indication of iodine–131 in samples 0–136 and 0–138, although at a substantially lower level. In the other 34 samples in this group, the levels were such that in no case was there a definite indication of the presence of detectable quantities of radioiodine.

Samples numbered 0–141 through 0–160 form Group II. These were collected when the environmental iodine–131 levels were elevated. Of these 20 samples, seven contained iodine–131 in quantities greater than the error of observation. The average for this group of 20 samples is 14.2 picocuries per gram; the average for the seven which are significantly greater than zero is 28.7 picocuries per gram. In contrast, the average for the first 37 samples (excluding number 0–104) is 3.0 picocuries per gram.

Discussion

Except as mentioned above, iodine–131 burdens of thyroid samples obtained from individuals who died before the middle of September 1962 were not significantly different from zero, reflecting the absence of measurable iodine–131 in the environment. The positive values noted from the middle of September 1962 to the end of October 1962 reflect the readily measurable environmental iodine–131 levels during that period. After the end of October 1962, iodine–131 concentrations in New England milk samples (*2*) began to recede. However, a drop in iodine–131 for the institutional diet sample (*3*) did not occur until after December. Since only five samples were obtained during this period, no conclusions can be drawn from them.

It may also be of interest to compare the observed iodine–131 levels in thyroids with appropriate radiation protection standards. Using the data of the International Commission on Radiological Protection (*5*), the dose to the thyroid from iodine–131 is 0.082 mrem/wk per pc/g of thyroid. On a yearly basis this is 4.3 mrem/yr per pc/g. A thyroid concentration of about 350 picocuries of iodine–131 per gram, maintained over a year, would therefore cause a dose equal to the Federal Radiation Council's Radiation Protection Guide (RPG) (*6*) of 1.5 rem/yr for individuals in an exposed population. Similarly, an average thyroid concentration of about 115 picocuries of iodine–131 per gram, maintained over a year, would produce the RPG (*6*) of 0.5 rem/yr to the average of an exposed population. The highest individual value in table 1, 58 pc/g, if sustained for a period of time on the order of one year, would represent about one-sixth of the RPG of 1.5 rem/yr for *individuals*. Similarly, the average of the 20 samples in Group II, 14.2 pc/g, if sustained for one year, would represent about one-eighth of the RPG of 0.5 rem per year for an average *of an exposed population*.

While these measurements of the iodine–131 content of *post-mortem* thyroids represent direct measurements of the presence of this nuclide in an extremely limited portion of a population, caution should be taken in extending the data beyond the actual samples involved. Since these thyroids were obtained from a moribund population, the dietary intake and metabolism of iodine–131 may be far different from those existing in the general population. Thus, the thyroid burdens of iodine–131 in hospitalized patients cannot be assumed to be representative of those existing in the population at large.

148

Summary.

Fifty-seven thyroid samples were made available by three New England hospitals during the period May 14, 1962 through January 10, 1963. Up to the middle of September, iodine–131 was detected in three out of 37 samples (range 47 to 51 pc/gram). Positive values for iodine–131 were found in 6 out of 15 *post-mortem* thyroids from September 15 through October 26 (range 41 to 58 pc/gram). From November 4 through January 10, 1963, one positive value (29 pc/gram) of iodine–131 was noted among 5 samples collected. The highest individual thyroid burden noted represented about one-sixth of the RPG of 1.5 rem/yr, and the average of 20 samples after September 15, 1962 represented about one-eighth of the RPG of 0.5 rem/yr.

Acknowledgements

The measurements of iodine–131 in the thyroids were performed by the Northeastern Radiological Health Laboratory's Analytical Services Section, under the direction of Mr. Edmond J. Baratta. Mr. Robert P. Chandler, Technical Editor, Radiological Health Data & Reports Staff, assisted in the preparation of the manuscript.

REFERENCES

(*1*) Eisenbud, M. Y., Mochizuki, A. S. Goldin, and G. R. Laurer: Iodine–131 Dose from Soviet Nuclear Tests, *Science, 136*:370–4 (May 4, 1962).

(*2*) Public Health Service: Radionuclide Analyses of Pasteurized Milk, *Radiological Health Data, 3* (September through December 1962). Also, Pasteurized Milk Network, *Radiological Health Data, 4*:23–6 (January 1963).

(*3*) Public Health Service: Radionuclides in Institutional Diet Samples, *Radiological Health Data, 3*:471–6 (December 1962). Also, *Radiological Health Data, 4*:177–82 (April 1963).

(*4*) Radiation Surveillance Network: *Monthly Tabulation of Findings*, Division of Radiological Health, Public Health Service, Washington, D. C. (Distribution by official request).

(*5*) International Commission on Radiological Protection: Report of Committee II on Permissible Dose for Internal Radiation (1959), *Health Physics, 3*:1–380 (June 1960).

(*6*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. (September 1961) price 20 cents.

149

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. A summary follows for Shippingport Atomic Power Station.

Releases of radioactive materials from the Shippingport Plant are regulated in accordance with standards set forth in the Federal Register Title 10—Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—MAXIMUM PERMISSIBLE CONCENTRATIONS OF EFFLUENTS DISCHARGED TO THE SHIPPINGPORT PLANT ENVIRONMENT[a]

Radionuclide	Water (pc/liter)	Air (pc/m^3)
Hydrogen-3 (tritium)	3,000,000	—
Xenon-133	—	300,000
Mixture of unidentified radionuclides	10	—
Mixture, if Ra^{226} and Ra^{228} are not present[b]	100	—
Mixture, if Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, Bk^{249} are not present[b]	—	100

[a] The concentration standards given here were taken from The Atomic Energy Commission's regulation 10 CFR Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies the concentration of the nuclide is small compared with its appropriate MPC. According to AEC regulation (Federal Register, Title 10, Part 20, August 9, 1961), a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than 1/4.

Shippingport Atomic Power Station, July 1962-June 1963

Duquesne Light Company, Shippingport, Pennsylvania

Environmental radiation monitoring at the Shippingport Atomic Power Station began with a two-year preoperational survey program to establish background levels at the site of the world's first large-scale nuclear-powered electric generating station. Following initial operation of the plant in December 1957, this program was continued as originally conceived through the third quarter of 1961, when it was determined that fewer sampling locations closer to the plant would provide equal or better evaluation of the effects of plant operation on the environment.

Release of Radioactive Materials to the Atmosphere

Controlled releases of xenon–133 were made periodically at a concentration of 130,000 pc/m^3 at the stack. A total of 12.1 mc Xe^{133} were discharged during the second half of 1962 and 406 mc during the first half of 1963.

The exhaust from an incinerator for burning contaminated combustible material is passed through a wet scrubber and a high efficiency filter before entering the stack. The average gross radioactivity of incinerator effluent during operation was 27 pc/m^3 during the second half 1962 and 18 pc/m^3 during the first half 1963.

Air Monitoring

Airborne particulates are sampled at three area monitoring stations by means of a continuously moving paper tape sampler with an end-window Geiger-Mueller detector and recorder. A one-half hour decay time is allowed before counting, hence, naturally-occurring radon and thoron daughters would be present. Six month average activities are given in table 2. Area monitoring stations 1, 2, and 3 are located 150 yards southeast, 150 yards west and one-half mile north-northwest of the stack, respectively.

TABLE 2.—GROSS BETA IN AIR

[Average concentrations in pc/m³]

Station number	Second half 1962	First half 1963
1	1.0	1.0
2	not operating	1.3
3	1.5	1.4

Fallout Sampling

Monthly pot samples were collected at each of the three area monitoring stations (same locations as for air). Gross beta average monthly deposition rates are given in table 3.

Liquid Radioactive Waste Disposal

Continuous controlled discharges of tritium and other unidentified radioactive wastes are made into the Ohio River. The quantities of discharge and average effluent concentration are given in table 4.

Ohio River Water Monitoring

River water samples were collected by a continuous samples upstream at the Shippingport condenser cooling water intake and by grab sampling downstream at the condenser cooling water outfall. (The downstream continuous sampler was not functioning.) These samples were analyzed weekly for both alpha and beta, suspended and dissolved radioactivity. The six month averages of these measurements are given in table 5.

TABLE 3.—GROSS BETA IN FALLOUT

[Average monthly deposition in nc/m²]

Station number	Second half 1962	First half 1963
1	199	276
2	209	340
3	193	372

TABLE 4.—LIQUID WASTES DISCHARGED INTO THE OHIO RIVER

	Tritium		Unidentified radioactivity	
	Second half 1962	First half 1963	Second half 1962	First half 1963
Total discharge (mc)	621	1,381	51	106
Average of monthly average concentrations of effluent (pc/liter)	172	61	1.8	4.4

TABLE 5.—RADIOACTIVITY IN OHIO RIVER WATER

[Average concentrations in pc/liter]

	Location	Alpha		Beta	
		Second half 1962	First half 1963	Second half 1962	First half 1963
Suspended solids	Upstream	0.13	8.79	5.0	33.8
	Downstream	0.14	1.24	7.8	31.8
Dissolved solids	Upstream	0.86	0.86	24.6	25.3
	Downstream	0.64	1.23	28.8	32.3

Previous coverage in *Radiological Health Data*:

Period	Issue
1959	*July 1960*
First quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*October 1961*
First and second quarters 1961	*April 1962*
Second half 1961 and first half 1962	*May 1963*

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1964

One nuclear detonation was announced by the U. S. Atomic Energy Commission during February 1964. This test was of low intermediate (20 to 200 kilotons) yield and was conducted underground at the Nevada Test Site on February 20 as part of the Commission's "Plowshare Program" to develop peaceful uses for nuclear explosives. The test was one of a series to develop devices for use in possible later excavation experiments. Arbitrary reference number 150 was assigned by *Radiological Health Data.*